The Mill at Anselma

Miller's Guide

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Miller

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Wheat and Flour Basics

Wheat Varieties and Their Uses

Early wheat varieties grown in the eighteenth century in the mid-Atlantic states were all soft wheat. Although these older varieties are no longer grown, the modern wheat varieties grown in the mid-Atlantic states are still soft wheat. In fact, except for a region in western New York, almost all of the wheat grown east of the Mississippi is soft wheat, because of the moister climate. In the mid nineteenth century, hard wheat varieties were developed, which now account for seventy-five per cent of the total wheat production in the United States. These varieties are grown primarily in the drier climates of the central United States, from the Dakotas all the way south to Texas. Understanding the difference between hard and soft wheat is key to understanding different flours and their uses.

Hard wheat is not only harder to crack (as evidenced by chewing a soft wheat berry, then chewing a hard wheat berry), but it is harder in the sense that it contains a greater percentage of two important gluten forming proteins, **gliadin** and **glutenin**. Also, hard wheat contains less starch than soft wheat. When mixed with water, these water soluble proteins produce gluten, which traps air and gases formed by yeast, and causes bread to rise. Hard wheat is favored for making bread flour because of the higher percentage of protein and higher potential for gluten formation. Because of its greater protein content, hard wheat flour can absorb more water than soft wheat flour. This greater degree of hydration results in a larger amount of bread, by weight, for a given amount of flour. Hard wheat flours are often referred to as “strong flours”.

Soft wheat has lower protein content, but higher starch content. Soft wheat flours are favored for crackers, cookies, cereals, pies and cakes and other pastry applications where softness of the product is favored over strength. Interestingly, from an international perspective, the flours used in western European countries, notably France, are still soft wheat flours, even for bread. In our area, much of the soft wheat is grown for the local pretzel industry. Soft wheat flours often are referred to as “weak” flours because of their reduced gluten forming capability.

Another distinguishing characteristic of different wheat varieties is spring wheat and winter wheat. Spring wheat is planted in the spring and harvested in the fall. Winter wheat is planted in the fall, and begins to grow, but goes dormant over the winter. It resumes growing in the spring and is harvested in the early summer. Winter wheat varieties are grown in more moderate climates where winters are less severe. One advantage of winter wheat is that livestock can graze on the grass before the grain head develops. Spring wheat generally has a higher protein content and is favored for bread flours.

Finally, there are red and white wheat varieties. Red wheat has a slight astringency associated with the pigment of its seed coat which has been bred out in white wheat.

Hard white wheat flours are favored for artisan breads, for example, where a sweeter taste is desired.

Although there are thousands of varieties of wheat grown in the United States, they generally fall into six main categories:

Hard Red Winter
Hard Red Spring
Soft Red Winter
Durum
Hard White
Soft white

Summary of Hard Wheat and Soft Wheat Characteristics

	Hard Wheat	Soft Wheat
Protein Content (Gluten Potential)	High	Low
Starch Content	Low	High
Principal Usage	Bread	Pastries, Biscuits, Pies, Cakes
Percentage of US Crop	75%	25%

Summary of Wheat Variety Properties

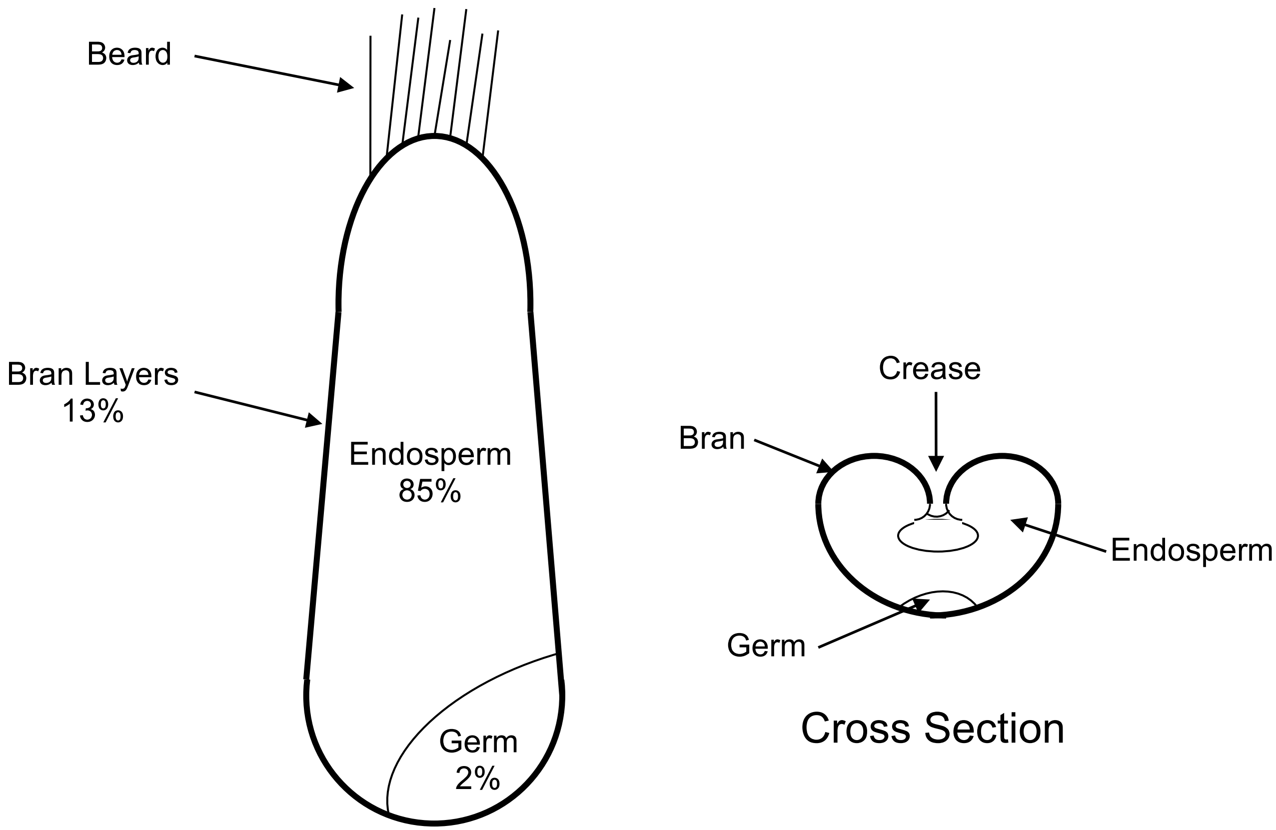
Variety	Where Grown	Average Protein Content	Uses
Hard Red Winter	Montana South Dakota Colorado Nebraska Kansas Oklahoma Texas	11 – 12 %	All Purpose Flours
Hard Red Spring	Montana North Dakota South Dakota Minnesota	13 – 14 % as high as 16 %	Bread Flours and High Gluten Flours
Soft Red Winter	Eastern US	10 %	Cake and Pastry Flours, Crackers, Snack Foods
Durum	North Dakota	15 %	Used to Make Semolina Flour for Pasta
Hard White	California	11 – 12 %	Mild Tasting Whole Wheat Products, Artisan Breads
Soft White	Northwest Western New York	10 %	Flat Breads, Cakes, Pastries, Crackers, Noodles

Wheat and the Wheat Berry

Wheat is a member of the grass family, and grows to a height of 24 to 36 inches. The shorter varieties are preferred because they are less likely to bend and are less susceptible to wind and rain damage. Also, shorter varieties are easier to harvest. When wheat is harvested, either in the early summer in the case of winter wheat, or in the fall, in the case of spring wheat, the threshing process separates the wheat berries from the rest of the stalk.

The wheat berry itself is a hard nut-like seed about a quarter of an inch long. The outer coating consists of layers of bran which protect the starchy core, the endosperm, which is the source of white flour. The endosperm consists of starch granules and gluten forming proteins. The germ is the regeneration mechanism. If the berry were planted, as a seed, the germ would begin the growth of the new plant, with the endosperm providing the nutrients.

Once the wheat berries are gathered and cleaned, the milling process can begin. The whole objective of the milling process is to crack open the wheat berry and extract as much of the endosperm as possible, separating it from the bran. The endosperm makes up approximately eighty-five percent of the wheat berry by weight, hence the theoretical yield is eighty-five percent. In practice, however, it has never been possible to extract more than seventy-five percent, even with state-of the-art milling technology.



Anatomy of a Wheat Berry

Milling

Introduction

The basic milling process consists of cleaning the grain, then grinding the grain, then sifting or bolting the resulting meal into various flour products. Actually, a fourth step probably should be added which is packaging.

Cleaning

The objectives of the cleaning process are to remove unwanted debris from the incoming grain (separating) and to remove dirt which adheres to the berries (scouring). Scouring includes removing the beard as well as the dirt which collects in the crease of the wheat berry. In the early days of milling in this country, in the seventeenth and eighteenth centuries, the cleaning process was crude at best. In the early to mid nineteenth century, mechanized grain cleaners, or ”scourers” as they were known, began to appear. Our scourer is one such example. It is called a “smutter”, because one of its functions was to remove the smut fungus which was prevalent in wheat. It also separated out chaff and other lighter debris which were blown out from the wheat. A chute for this purpose can be seen attached to our smutter which conducts the lighter debris to an opening in the wall where it was blown to the outside. Another early form of scourer was the rolling screen which closely resembles a cylindrical bolter, but with a much coarser screen. A grain cleaner commonly found in antique shops is the hand-cranked fanning mill, also known as a winnower. In the mid nineteenth century, a great number of patents were issued for very much more complicated machines known as separators. Basically, these machines consist of a series of sieves of varying mesh sizes. The coarse mesh separates out the bulk debris, allowing the grain to pass through. Subsequently, finer meshes allow fine dirt particles and tiny grains to pass through, leaving the desired grain above. The addition of large fans greatly improved the efficiency of these separators.

Grinding

The basic stone grinding operation with which we are familiar was known to have been in use by the Romans, who are thought to have introduced the idea to Britain. That is, a runner stone rotates over a fixed bed stone, with the grain entering the eye. The stones used by the Romans even had radial grooves, though not the complex dressing with shaped furrows that have been in use in the recent past. Also, Roman stones were fifteen to twenty inches in diameter, not four to five feet in diameter as we know them.

The grinding operation begins when the grain enters the eye of the stone and becomes trapped between the runner stone and the bed stone. The furrows usher in the grain between the stones, where the grain is subsequently cracked and ground. The purpose of the furrow is threefold: to distribute the grain, to provide ventilation to cool the grain, and to cut the grain. If the furrow is viewed as a cross section, the grain gradually moves up the incline of the furrow where it is cut near the feather edge. When the cracked grain reaches the land, it is ground between the lands of the runner stone and the bed stone. The cracking lines provide a sharpness to the lands which aids in the grinding process. Stones intended for grinding wheat will have upwards of sixteen lines per inch, while stones intended for grinding corn will have lines which are coarser, typically three to six lines per inch. If one were to follow the path of a wheat berry from the time it enters the eye of the stone to the time the ground wheat berry exits the stone, it follows a spiral trajectory.

There are many different types of millstone dress, and each miller had his favorite. Ours happens to be the very simple straight dress. Regardless of the particular choice of dress, the pattern is exactly the same for the runner stone and its mating bed stone. When the runner stone is inverted over the bed stone, a shearing action takes place between the feather edges of the stones as the runner stone rotates. The furrows are not laid out radially from the center of the stone, but are laid out to be tangential to an imaginary circle within the eye of the stone. The radius of this imaginary circle is called the draft. The greater the draft, the faster the grain moves to the periphery of the stones as it is cut and ground, and the more power is required.

World wide, there are quite a number of sites where mill stones were quarried, including a site near Cologne on the Rhine where millstones were quarried by the Romans, as well as various locations in England and the United States. But, by far the most important site of all, was the La Ferte-sous-Jouarre site in the Marne valley in northern France. The millstone material quarried there was a fresh water quartz material, extremely hard, and porous. This material was not quarried as an entire millstone, but was quarried in segments which were assembled on site by the millwright. Plaster of paris was used to cement the segments together, and to provide a backing to the stones, and steel bands were heat shrunk around the periphery, or skirt. This material was highly valued for making superfine white flour because of its hardness and because of the porosity of the stone surface. The edges of these pores tend to be sharp, and, as a result, they tend to shear the grain rather than abrade it. In terms of the flour product, this means less finely powdered bran in the flour, which resulted in a higher quality, whiter flour product. Furthermore, as the stone faces wore away, new pores with fresh cutting edges appeared. Because of this, the French buhr stones were more forgiving in terms of the need for frequent dressing. In our mill, we have two run of French buhr stones, and one run of granite stones. As far as we know, the two run of buhr stones were used in making flour, and the granite stones were used for making feed and corn meal.

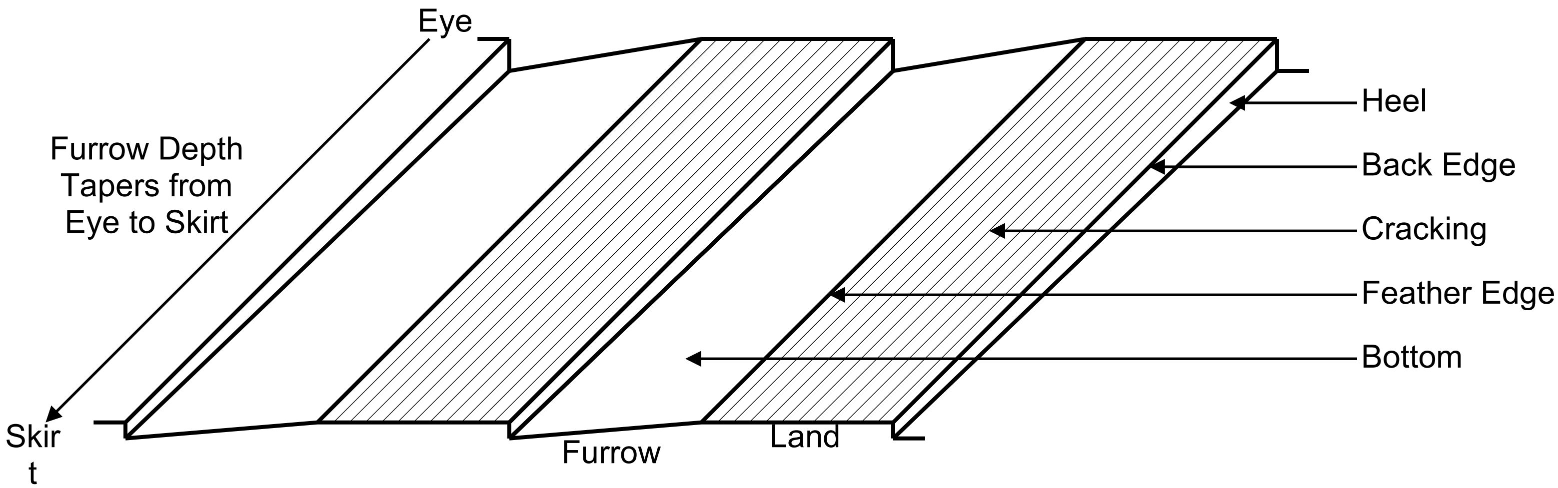
Bolting

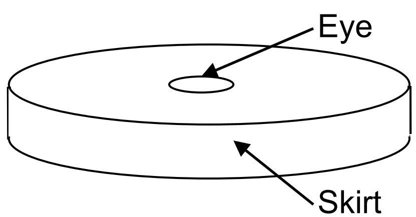
The purpose of the bolting, or sifting operation, is to divide the incoming meal into various grades, typically three: very fine flour, along with some very fine bran impurities, a coarser flour, with some midlings, and coarse midlings. Midlings are starchy chunks of endosperm, which may still have bran attached, and which contain a significant amount of potential flour. The tailings, as they are called, are the waste products that don't make it through these three meshes, which consist of the beard, germ, bran, and dirt contaminants. The coarser products could be reground, if the miller so chose, and there is evidence in our mill that a chute once existed to return the coarse products back to the stones from the auger beneath the bolter for this purpose.

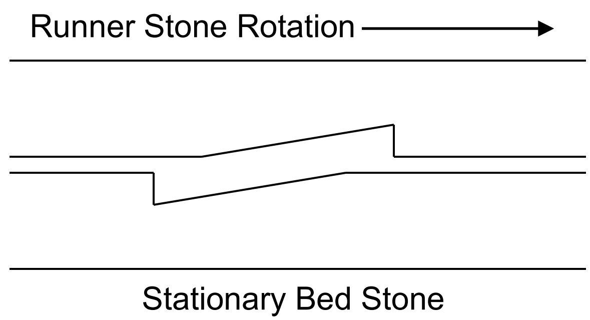
Bolting reels could be anywhere from six feet in length to well over twenty feet in length. Ours is fifteen and a half feet in length. The fine section is four and a half feet, the middle section is slightly less than eight feet, and coarse section is slightly greater than three feet. The reel is twenty-four inches in diameter, and would have rotated at approximately thirty revolutions per minute. The auger beneath the bolter reel transports the products horizontally into one of three different chutes below. The tailings exit through a separate chute at the lower end of the reel.

A major contribution to the milling process was made by the French millers who used a system of progressive grinding and bolting in three, or as many as seven stages. The meal was first ground and bolted with the stones set high. A high grade, superfine flour was produced from the bolter, and the tailings were sent back to the stones for a second grind, this time with the stones spaced closer together. Again, more flour was produced from a second bolting operation. The tailings were returned for yet a third grind, with the stones set even closer together, followed by a third bolting. This progressive grinding and bolting took a considerable amount of time, but produced a greater yield of higher quality flour. It also necessitated the use of multiple bolters. To further increase the quality of the flour, the stones were run at about half the speed of their American counterparts. French millers were not the only ones to use this progressive grinding and bolting process; millers in Hungary and Austria also employed similar processes.

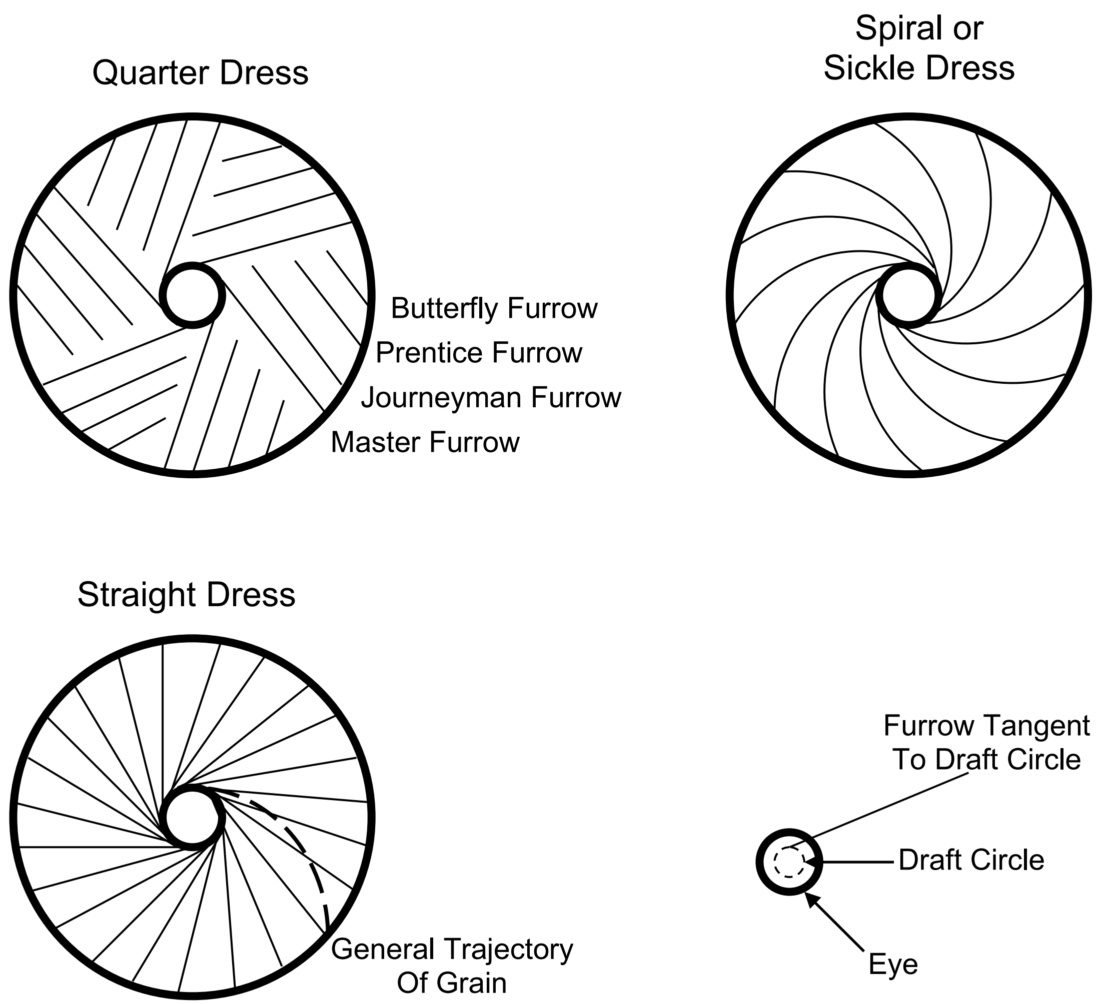
In our country, the most important objective of the miller has always been the highest yield of saleable flour per bushel of wheat, produced at the fastest rate. A bushel of wheat with the correct moisture content weighs sixty pounds, and in the recent past, millers have strived for a yield of forty pounds per bushel, or sixty-seven per cent. In the late eighteenth, early nineteenth centuries, millers were achieving only sixty per cent yields of fine flour. With improvements in the milling process, as advocated by Oliver Evans, this could be improved to sixty-four per cent. French millers, using multiple grinding and bolting operations were able to achieve yields of sixty-six per cent. Current extraction yields, in large mills using the most modern machinery, are as high as seventy-five per cent. To understand the importance of yield for these modern operations, imagine the impact of a one per cent yield loss when six to eight tractor trailer loads of flour are produced daily. This could be as high as several thousand pounds of flour per day!



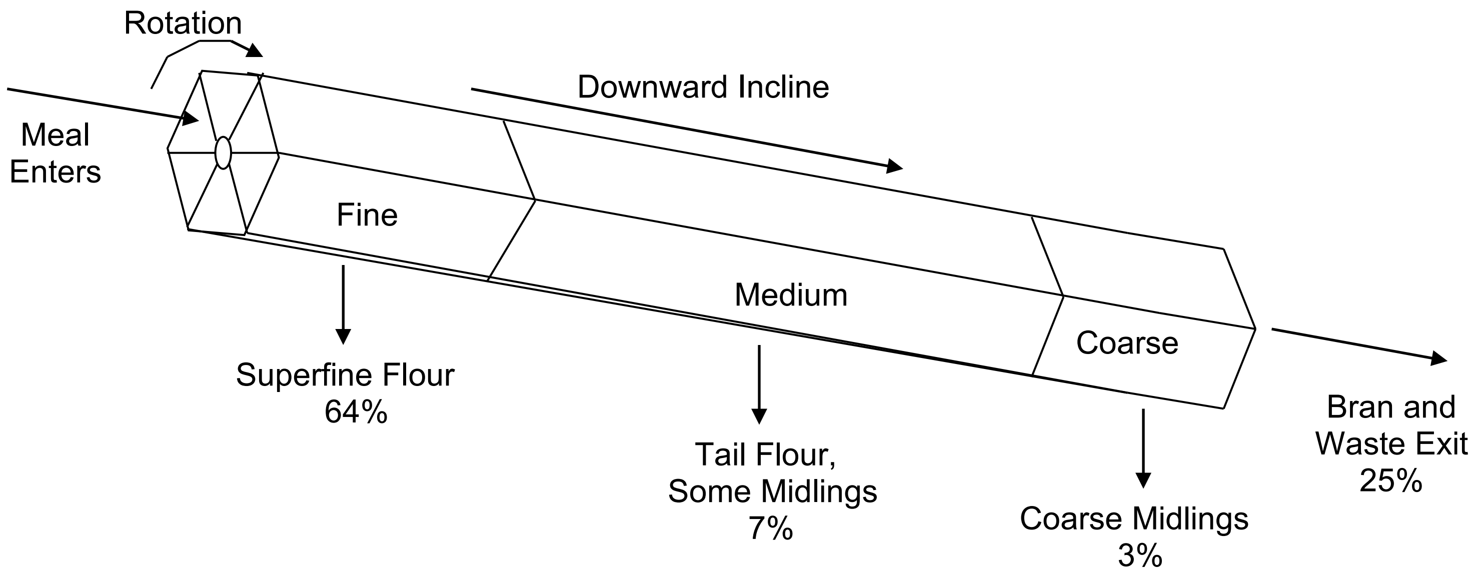




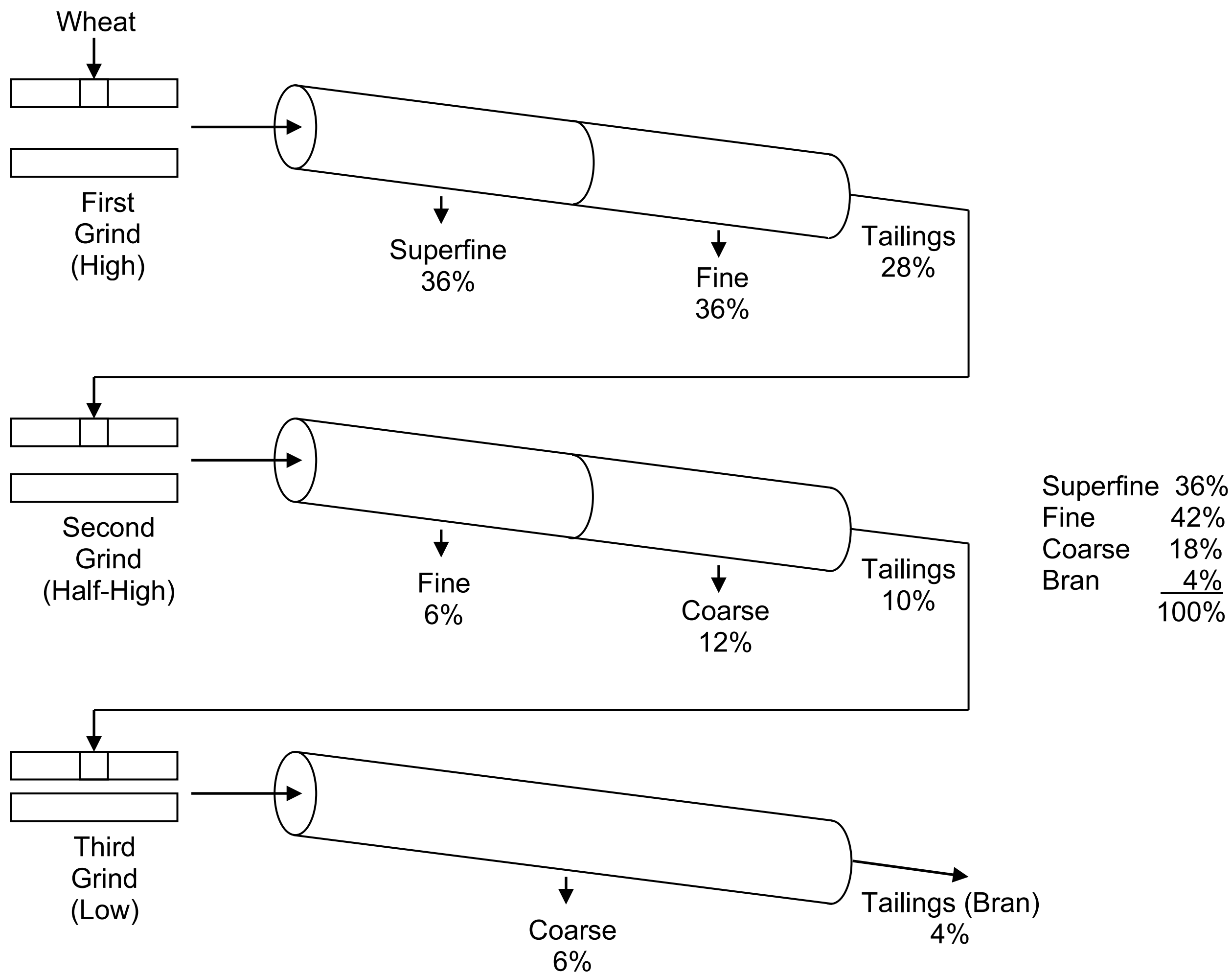
Mill Stone Details



Types of Mill Stone Dress


Rotation
Downward Incline
Meal
Enters
Fine
Medium
Coarse
Superfine Flour
64%
Tail Flour,
Some Midlings
7%
Coarse Midlings
3%
Bran and
Waste Exit
25%

Bolter Reel



Progressive Grinding and Bolting Process
Used in the French System

Historical Perspective

Up until the mid nineteenth century, the process used in this country was the **flat grind,** or **American grind** process. Either because millers in this country were unaware of other processes, for example those used in France, or because they were always striving for the highest production rates, they almost always processed the grain in a single grind. Because the grain was only ground once, it was necessary to set the stones close together to yield as much flour as possible in a single grind. The wisdom of the day seemed to dictate a single grind, stones close together, running very fast (150 rpms in some cases, compared with 90 rpms in our case), with a high feed rate. The result was that the meal often left the millstones hot and damp, and if the meal entered the bolter in this state, it would clog the bolting cloth. This necessitated some means to cool and dry the grain before bolting. This was often accomplished simply by shoveling the meal out onto an open floor until it cooled and dried. Where space permitted, Oliver Evans' hopper boy was used for this purpose. The hot damp meal was deposited at the edge of a large circular area, and a rotating arm with loosely fitting "flights" raked the meal slowly around on the floor within this area, gradually moving it toward the center where it would go through a hole in the floor to the bolter below. In our small mill, there is no area large enough to have accommodated a hopper boy, and there is no evidence of circular markings on the floor.

The key to the flat grind, or low grind process was to set the stones as close as possible to optimize the flour yield in a single grind, and minimize the amount of midlings produced. These midlings were either thrown out, or sold as feed, or they could have been reground to produce flour, though of a significantly lower grade. The miller also had the option of mixing this flour with the flour from the first run, but this, of course, reduced the quality of flour from the first run. If the miller raised the stones, the quality of flour produced from a single grind was improved, but at the expense of a greater quantity of midlings. In this case, the overall flour yield was less.

In the mid nineteenth century, varieties of hard wheat became available which posed yet another problem to the miller. The bran layer on these harder varieties was more brittle, and required a different approach to the milling process because the flat grind system pulverized the brittle bran which reduced the quality of the flour. The miller had to grind higher, but again, at the expense of a greater quantity of midlings and a lower yield. An invention from Austria, later called the midlings purifier, changed all of this, and led to one of the single most important advances in milling with the advent of the **New Process.**

The midlings purifier separated the midlings into heavier, purer midlings, medium weight midlings, and light midlings, through the use of air currents and sieves. Subsequently, the heavier, purer midlings, were reground on a set of stones employed for this purpose called middling stones, usually of smaller diameter, and with larger furrows and narrower lands. This New Process was a revolution in milling, and the resulting flour was called **patent** flour. For the miller used to the flat grind system, this was a major change; now his objective was to grind high, or half high, in order to produce as much midlings as possible. Later on, this New Process was adapted for soft wheat as well. It is unlikely, though, that our mill adopted the New Process for the locally grown soft wheat, since there is no evidence of middling stones or of a purifier.

The Milling Process at Anselma

Introduction

Historically, the granite stones we now use for milling were used for grinding feed for livestock. Even though the stones were dressed for this purpose, we have found ways to grind hard and soft wheat as well as corn with the existing stone dress.

Our primary objective is the preservation of the machinery, and it must always be operated in a way that minimizes wear and tear on the gear train. If we are able to produce flour products in a way that is consistent with this objective, so much the better. In keeping with this, the machinery should always be operated with the following in mind:

- Run the machinery at a low speed, but with sufficient runner stone rpm to effectively utilize its inertia.

- Never let the stones touch.

- Operate with sufficient, but not excessive water power. This means controlling the water flow by setting the control arm to the "run" position, possibly one notch higher, but no more.

Our current process, which involves recirculating some of the ground meal back through and mixing it with the unground wheat in the hopper, minimizes the stress on the gear train. Also, we run the machinery more slowly, with a lower feed rate, than would have been done historically. Even for production, running the machinery any faster would serve no purpose, since the time limitations in our process are sifting and packaging, not grinding.

The focus in this section will be wheat flour production, since this is far more demanding in terms of machinery operation and subsequent processing than corn meal production. Corn meal is a coarser grind, and can be packaged as it comes out of the meal spout. To date, we have had no need to sift the product to make corn flour.

Cleaning and Set Up

Prior to grinding, the furniture will have been dismantled, and the entire area around the stones, inside the hoop, and inside the horse and shoe will have been thoroughly vacuumed. To the extent possible, the space between the stones will have been cleaned.

Recently, an important cleaning process has been added at the suggestion of other millers. This is a thorough wipe-down of the stones and furniture with a mild Clorox solution (three tablespoons per gallon). The areas to be wiped down include the curb, hoop interior, hopper, shoe, meal spout, as well as the sifting apparatus and screens. Once this is complete, the furniture can be reassembled and the crook line reattached, and a fifty-pound bag of grain can be loaded in the hopper.

Start Up

Before opening the control gate, the power train should be moved by hand to make sure that nothing is binding in the machinery, and the runner stone must be set at its highest position. At this point, the control arm can be dropped to the point where water just begins flowing over the wheel, then slowly dropped to the "run" position.

It takes between fifteen and twenty minutes for the cavity between the stones and the hoop to fill up with meal, and approximately half a bag (twenty-five pounds) of grain is consumed in this start-up process. During this time, the volunteer monitoring the shoe angle and the flow of grain into the eye must regulate the flow based on experience; sufficient flow is required to maintain an adequate grain bed between the stones, but not so much as to bog down the machinery and reduce the runner stone rpm.

When there appears to be a steady stream of meal out of the meal spout, the meal is recirculated to the hopper along with the unground grain, at the rate of approximately half grain, half meal. The two are mixed by hand in the hopper. After this mix has worked its way through the stones, the runner can be gradually dropped to the normal operating, low grind position. When meal of the desired fineness begins to emerge, it is collected for sifting.

Recirculating the meal and mixing it with the unground wheat is a very important part of the Anselma process using the granite stones and the existing dress. Grinding the wheat alone hasn't worked, and regrinding coarse meal alone bogs down the machinery and takes two volunteers just to manually feed the meal into the eye. Interestingly, we discovered this technique quite by accident, although further research revealed that Oliver Evans actually suggested this process. We still are not sure why it works!

Processing the Meal into Flour

The meal is separated into flour products using a motorized plansifter, very much like those used one hundred years ago. It has a coarse screen placed over a fine screen. The flour product which makes it through both screens is fine white flour which then can be packaged. The product which makes it through the coarse screen, but not the fine screen, is largely bran. This can be added to the fine white flour at the rate of approximately two large scoops per tub of fine white flour to make whole wheat flour. The two are mixed by hand. Otherwise, this product can be recirculated to the hopper as part of the fifty-fifty mix with the unground wheat. The product which doesn't make it through the coarse screen constitutes coarse bran and midlings, which can be packaged as such, or recirculated, or discarded.

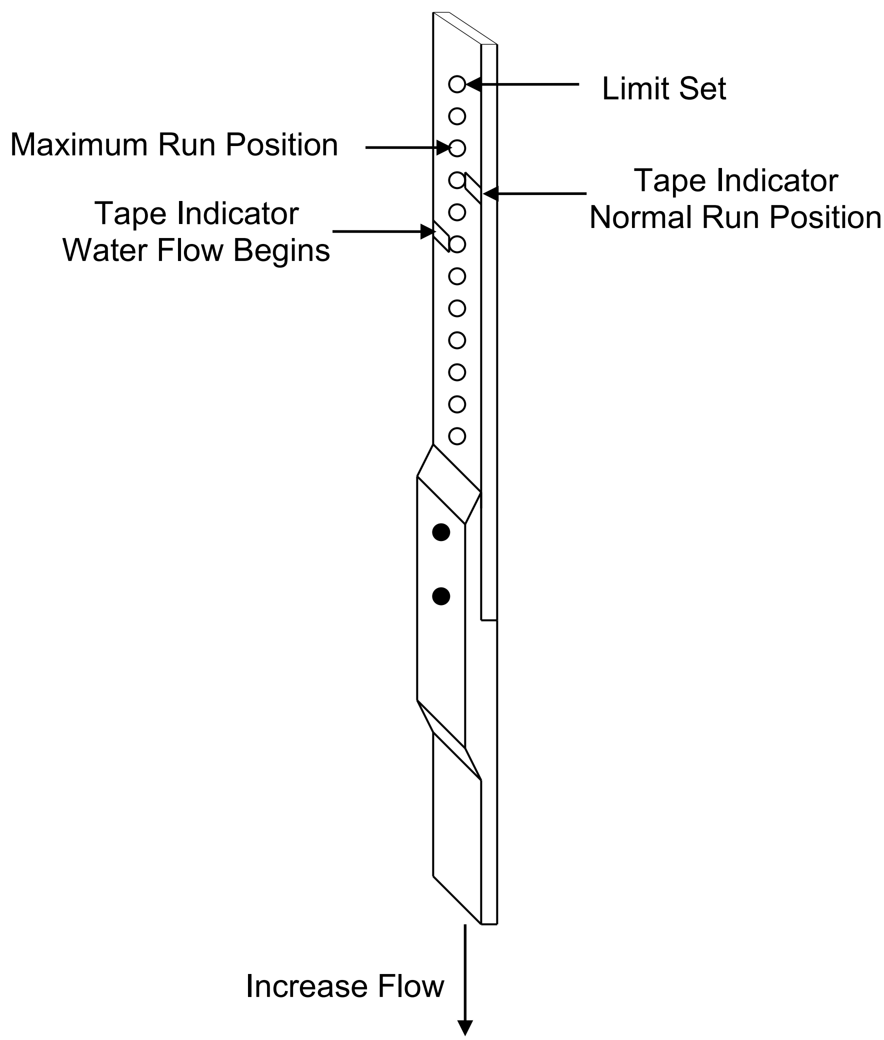
When everything is running smoothly, and the runner is at a low grind position, the meal from the spout may be sufficiently fine to be packaged as whole wheat flour directly, without further sifting. This must be carefully considered, because the fineness or coarseness of the flour can have a significant impact on baking qualities, particularly in bread making and gluten formation, for example.

Problems

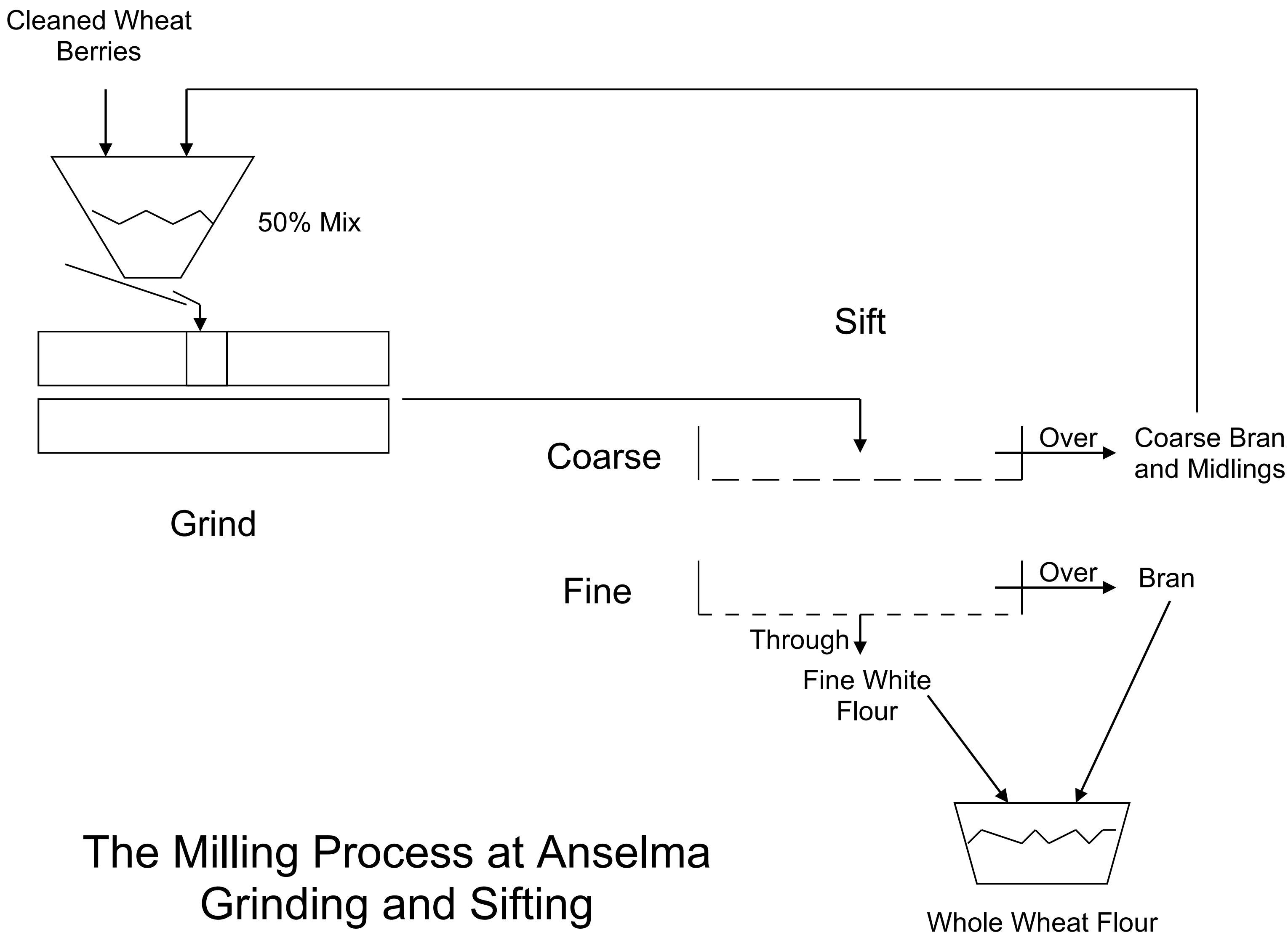
For some unknown reason, the machinery occasionally bogs down, even with a steady, constant flow of grain into the eye, and a constant flow of water over the wheel. In these situations, there is no alternative but to raise the runner stone and let the grain clear itself out while reducing the flow of grain into the eye. Essentially, this means repeating the start-up procedure.

Meal and Flour Products

Product	Ingredients
Corn Meal	Locally Grown Corn Roasted at 260 Degrees
Whole Wheat Flour	Locally Grown Soft Winter Wheat
Hard Wheat Flour	Hard Red Spring Wheat
Soft Wheat Flour	Locally Grown Soft Winter Wheat
All-Purpose Flour	50-50 Mix of Hard Wheat Flour and Soft Wheat Flour
Wheat Bran	Either Soft or Hard Wheat



Water Flow Control Arm
Peg Positions For Startup and Run



The Milling Process at Anselma
Grinding and Sifting

Stone Ground Flour and Commercial Flour

At the Mill at Anselma, our purpose for grinding grain is to demonstrate to our visitors how the mill operated during its history, and to give them an idea of what stone grinding is all about. In that sense, any discussion of modern milling is out of place, except that we are frequently asked by our visitors what the difference is between flour produced by stone grinding and flour produced by modern roller milling. It is certainly not our objective to provide an in depth knowledge of roller milling and commercial flour production, but it is important to have a sufficient knowledge to answer these questions.

If the objective of milling is to produce the purest, whitest flour, free of bran and germ, roller milling wins hands down. In stone grinding, there is no way to separate out the germ, and despite the miller's best efforts, fine bran will still be found in his best white flour. From a nutritional point of view, of course, flour is a healthier product if it contains the bran and the germ. Because of the near total extraction of the bran and the germ and their nutrients in the case of roller milling, these nutrients must be added back in. In fact, the government requires that flour be enriched with the following additives: B-complex vitamins, thiamin, riboflavin, niacin, and folic acid.

One of the key reasons that the germ is removed in modern milling is to prolong shelf life. Wheat germ contains oils which lead to rancidity of the flour product. In our case, since the germ is not removed, we recommend refrigerating the product or, better yet, freezing the product until it is to be used. We also recommend a "use by" date of six months from the time the flour is produced.

In spite of the fact that natural nutrients are removed in the modern milling process, roller milling is far better adapted to commercial baking, because flour products can be uniquely formulated for specific commercial baking needs. Streams of flour emerging from various roller stands can be mixed to provide the desired protein level, or starch level, for example. Also, the grades of flour are more easily separated out, ranging from the finest patent flour produced at the first break, to clear flour produced at later breaks, to lower grades of flour which may be used in combination with other flours.

Whether flour is milled using stones, or milled using rollers, it should not be used in its fresh, or "green" state, but it should be allowed to oxidize. This oxidation gives dough its elasticity during gluten formation. Otherwise, bread dough won't spring back after it is stretched, and instead will go slack. In our case, oxidation, or aeration occurs somewhat naturally over a period of several weeks. To promote oxidation, our flour should be shaken, or turned over periodically. Again, it is best that the flour be kept cold as it oxidizes, because oxidation accelerates rancidity. In the case of commercial flour production, oxidation is greatly accelerated through the addition of chemicals, one of which is potassium bromate. Flours so treated are called bromated flours. Oxidation also occurs during the flour bleaching process if the bleaching agent is chlorine. Bleached flours work well for commercial bread making because these flours reduce yeast fermentation times, and are better suited to high speed mixing. Cake flours actually benefit from bleaching because it enables the wheat starches to absorb more water, resulting in moister cakes.

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