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Module

on

Wheat milling and testing

By

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Text

Introduction:

Milling is an ancient art. In simple terms, its objective is to make cereals more palatable and thus more desirable as food. The aim of milling of any cereals is

1. To grind cleaned and tempered cereal
2. To completely separate the bran and germ from the mealy endosperm which is then thoroughly pulverized into middlings, semolina and flour in case of wheat.

Milling of wheat:

Wheat (*Triticum aestivum, Triticum durum*) is a single-seeded fruit, 4- to 10-mm long, consisting of a germ and endosperm enclosed by an epidermis and a seed coat. The fruit coat or pericarp (45- to 50-um thick) which surrounds the seed and adheres closely to the seed coat. The colour of wheat depends on the species and other factors. Hence, there are red to white wheat. The colour is due to material present in the seed oat. Wheat also is classified based on physical characteristics such as red, white, soft, hard, spring, or winter. The wheat kernel structure is shown in Fig. 1.

The outer pericarp is composed of the epidermis and hypodermis. The epidermis consist of a single layer of cells that form the outer surface of the kernel. On the outer walls of the epidermal cells is the water-impervious cuticle. Some epidermal cells at the apex of the kernel are modified to form hairs. The hypodermis is composed of one to two layers of cells. The inner pericarp is composed of intermediate cells and cross-cells inward from the hypodermis. Long and cylindrical tube cells constitute the inner epidermis of the pericarp. In the crease, the seed coat joins the pigment strand, and together they form a complete coat about the endosperm and germ. Three layers can be distinguished in the seed coat: a thick outer cuticle, a “colour layer” that contains pigment, and a very thin inner cuticle. The bran comprises all outer structures of the kernel inward to, and it includes, the aleurone layer. This layer is the outer layer of the endosperm, but is considered as part of the bran by millers. The aleurone layer is usually one cell thick and surrounds the kernel over the starchy endosperm and germ. The endosperm is composed of peripheral, prismatic, and central cells that are different in shape, size, and position within the kernel. The endosperm cells are packed with starch granules, which lie embedded in a matrix that is largely protein. Wheat grain contains 85 percent endosperm, 3 percent germ and 12 percent bran, all three nutritious in their own way **(Table. 1).**

Milling Process:

Wheat is commonly consumed in the form of flour obtained by milling the grain while a small quantity is converted into breakfast foods, such as wheat flakes, puffed wheat and shredded wheat.

Two main objectives of wheat milling are:

- to separate endosperm of the grain from bran and germ
- to reduce dimensions of endosperm particles for fine flour particles

There are two types of milling process for the wheat i.e. traditional milling and modern milling. Let us know about them in detail.

Traditional Milling:

The traditional procedure for milling wheat in India has been stone grinding (chakki) to obtain whole meal flour (atta).By this method 90 – 95 percent extraction rate of flour is obtained. Almost all the nutrients of the grain remains intact in this process, but indigestible portions like cellulose, and phytic acid which binds to required nutrients like minerals are removed simultaneously. Therefore, Indian style flour is not technically 'whole wheat' but superior to the usual whole grain flour that is produced by simply grinding everything to a fine powder. However, stone grinding is gradually replaced by power driven small and big chakki which in turn has been replaced by modern flour mills.

Modern Milling:

Modern milling process consists of the following steps:

1. Grain cleaning
2. Tempering or conditioning
3. Roller milling

4. Sieving
5. Commercial flours mixing

Grain cleaning: Wheat separators and destoners, or a combination cleaner and good aspiration are used to remove dust and large impurities. Grain contains various types of impurities together with damaged, shrunken and broken kernels. The process of separating these impurities is collectively known 'screenings'. A magnetic separator removes any tramp metal. A milling separator removes sticks, stones and other foreign material which is either larger or smaller than the grain being cleaned. Basically, this machine removes chaff, small pieces of straw etc by aspiration. The grain is then fed into a sieve larger than the desired grain, which removes large material, including other larger grains. The next sieve retains the desired grain but removes smaller grains, by allowing them to pass through. The sieves move both side i.e back and forth. Optical sorters are more efficient than disc or cylinder separators to remove foreign seeds, ergot-infected durum kernels and other discolored impurities thus, limiting the loss of expensive high quality durum wheat and improving semolina quality.

Overall, there are six different principles of separation, used in wheat cleaning. These include separation based on differences in size, shape, terminal velocity in air currents, specific gravity, magnetic and electrostatic properties, colour, surface roughness etc. The total quantity of screenings amounts to 1-1 ½ percent of the grain fed to the machine.

Tempering or conditioning: The term conditioning implies the use of heat in conjunction with water to mellow endosperm. To improve the physical state of grains for milling, conditioning or tempering of wheat precedes the actual milling process. This process involves the addition or removal of moisture for definite period of time to obtain desired moisture content in grain.

Roller Milling: The grinding of most cereal grains, particularly having a crease, is done with a roller mill. Around the year 1850 first time in Switzerland and later in Hungary the concept of using porcelain or steel rollers came to existence,instead of millstones.

Roller mills have following advantages over traditional stone-mills.

1. The capacity of roller-mill is much larger than that a windmill or water mill.

2. The range of products from a roller mill is larger and better in quality for industrial processing.
3. Roller-miller does not require the laborious and time consuming sharpening of the furrow edges of the millstones.

Main stages of roller milling are:

Breaking stages - grain is opened mainly by shearing to produce 4 – 5 breakings resulting in coarse parts of grain, small part of endosperm as pure semolina with very small amount of flour
Reduction stages - intensive extraction of all resting parts of endosperm and finally also aleurone layer to produce smooth flour.

The Reduction System: The reduction system aims to reduce coarse endosperm particles (semolina and middlings) to flour fineness. It involves a series of reduction steps, in which, as in the case of breaking, the rollers are set progressively closer at each successive processing step. The reduction rollers also operate in pairs. They have smooth, slightly roughened (mat) surfaces and speed differentials are 4:5 (in Europe) or 2:3 (in USA and Canada). After each grinding pass, the stock is sifted, the flour removed, and the coarser particles sent to the appropriate reduction roll. Purifiers are also used after reduction rolls, mainly to classify the middlings according to size. The reduction process is repeated several times until ultimately most of the mealy endosperm has been converted to flour. End products of the reduction system are mainly fine offals (shorts) and fine endosperm particles (flour).

Sieving: A sieve is known as plansifter which is a complex assemble of sieves allowing to collect single fractions as "oversieve" or "undersieve".

Commercial flours mixing: During Commercial milling Flour is obtained in every step of breaking, reduction and purification in different percentages. Ash content and color change with first breakings which is lighter with low ash to the last reduction where the flour is dark and with high ash

Commercial flours for distribution have prescribed ash content thus the flour produced at each stage needs to be mixed to get standardised flour based on the end users requirements. Classification of commercial flours is professional international units designated as T with a number. The number represents the percentage of ash content multiplied by 1000. E.g. T 550 means ash content of 0.55 % x1000. Hence for industries grades like T530, T600, T700, T1050 etc are widely available.

Milling quality standardization: In commercial milling, maximum yield of flour with a 'healthy' white colour is major requirement. Lower the ash content, the whiter the flour. The milling quality of wheat is determined by successively measuring the following characteristics in a standard milling process.

1. The amount of grain that can be milled per unit time.
2. The flour yield of each milling passage and
3. The moisture and ash content of each milling passage.

Automation of wheat milling: In traditional mill control of ash content is mainly through streams regulated by setting of gap between rollers, different sieves

In modern mill setting of rollers and streams is standard and control with the computers is based mainly on standard streams in single stage.

Types of white flours

There are many types of white flours, as explained herewith

- **All-purpose flour (plain, white):** Made from a blend of hard and soft wheat's, this type of flour has a moderate amount of protein and starch content that makes it suitable for either breads or cakes and pastries.
- **Bleached flour:** When freshly milled, flour is slightly yellow. To whiten it, manufacturers let the flour age naturally. However, this stage is accelerated by adding chemicals, such as benzoyl peroxide or acetone peroxide.
- **Bread flour:** This is made entirely from hard wheat. A high gluten content helps bread rise higher because the gluten traps and holds air bubbles as the dough is mixed and kneaded.
- **Bromated flour:** Sometimes maturing agent such as bromate is added to flour to further develop the gluten and to make the kneading of dough easier. Other maturing agents include phosphate, ascorbic acid, and malted barley are commonly used.
- **Cake flour:** Finer than all-purpose flour, cake flour is made entirely from soft wheat. Because of its low gluten content, it is especially

well suited for soft-textured cakes, quick breads, muffins, and cookies.

- **Durum flour:** The highest protein content of durum flour can produce the most gluten. It is frequently used for pasta.
- **Farina:** Farina is milled from the endosperm of any type of wheat, except for durum wheat (which is milled to make semolina). Farina is primarily used in breakfast cereals and pasta.
- **Gluten flour:** Made so that it has about twice the gluten strength of regular bread flour, this flour is used as a strengthening agent with other flours that are low in gluten-producing potential.
- **Instant flour (instant-blending, quick-mixing, granulated flour):** Instant flour and mixes with liquids pours easily than other flours. It is used to thicken sauces and gravies, but is not good for baking because of its very fine, powdery texture with high starch content.
- **Pastry flour (cookie flour, cracker flour):** This flour has a gluten content slightly higher than that of cake flour but lower than that of all-purpose flour, making it well-suited for fine, light-textured pastries.
- **Self-rising flour**: Soft wheat is used to make this flour, which contains salt, a leavening agent such as baking soda or baking powder, and an acid-releasing substance. Self-rising flour should never be used in yeast-leavened baked goods.
- **Semolina**: This is the coarsely ground endosperm (no bran, no germ) of durum wheat. Its high protein content makes it ideal for making commercial pasta, and it can also be used to make bread.

Whole-wheat flour:

During roller milling, the bran and the germ gets separated from the endosperm, the three components actually have to be reconstituted to produce whole-wheat flour. (The germ and bran are visible in the flour as minute brown flecks.) Because of the presence of bran, which reduces gluten development, baked goods made from whole-wheat flour are naturally heavier and denser than those made with white flour. Many bakers combine whole-wheat and white flour in order to gain the attributes of both.

Testing of wheat flour:

The products of wheat milling are tested through analytical methods for determination of Moisture, ash, protein, gluten contents, Falling number and sedimentation value. Rheological parameters are evaluated using Farinograph, extensograph, alveograph, amylograph, Fermentograph, maturograph, spring oven test and baking tests.

Moisture: is determined gravimetrically, by heating the sample to 80^{0}C for 30 min and cooling the material in a desiccator. The difference in weight is expressed as moisture percentage
Ash: the material is completely burnt in a muffle furnace and the reside left is known as ash
Gluten/ Protein: Gluten is responsible for the elasticity and extensibility characteristics of flour dough.

Combustion Nitrogen Analyses (CNA) is one of several methods used to determine protein content in flour or wheat.

The wet gluten test: this provides information on the quantity and estimates the quality of gluten in wheat or flour samples.

Wet gluten reflects protein content and is a common flour specification required by end-users in the food industry.

Falling number: Viscosity analysis - the falling number instrument analyzes viscosity by measuring the resistance of a flour and water paste to a falling stirrer. This is dependent on the enzymes in the flour. The level of enzyme activity measured by the Falling Number Test affects product quality. Eg Yeast in bread dough requires sugars to develop properly and therefore needs some level of enzyme activity in the dough. Since starch provides the supporting structure of bread, too much activity results in sticky dough during processing and poor texture in the finished product. If the falling number is too high, enzymes can be added to the flour to compensate. If the falling number is too low, enzymes cannot be removed from the flour or wheat, which results in a serious problem that makes the flour unsuitable.

Sedimentation value: Swelling of the gluten fraction of flour in lactic acid solution affects the rate of sedimentation of a flour suspension in the lactic acid medium. Higher gluten content and better gluten quality both give rise to slower sedimentation and higher Sedimentation Test values.

Farinograph: The farinograph is a tool used for measuring the shear and viscosity of a mixture of flour and water. The primary units of the farinograph are Brabender Units, which is an arbitrary unit of measuring the viscosity of a fluid.

Extensograph: The Extensogram, records the exerted force as a function of the stretching length (time). This helps in understanding the flour quality and the suitability of the flour for the production of various products. This also helps in understanding the influence of flour additives on the flour characteristics.

Alveograph: The Alveograph, is a tool for flour quality measurement. It measures the flexibility of the dough produced from the flour, by inflating a bubble in a thin sheet of the dough until it bursts. The resulting values show the strength of the flour, and thus its suitability for different uses.

Amylograph an instrument that measures and records the gelatinization temperature and viscosity of pastes of starch and flour

Fermentograph: The Fermentograph measures the production of CO_2 during dough fermentation as necessary for fluffing up the dough.

Maturograph: Maturograph measure in detail the individual phases of the baking process with the Maturograph a measured in dough by Amylograph, Farinograph and Extensograph

Spring oven test: The oven spring apparatus is used for the volume determination of the optimal proofing loaf (based on the maturograph results) and its changes during baking in oil bath with temperature increasing from 30°C to 100°C.

Baking test. The baking involves high speed dough mixing and a short fermentation time. Dough pieces are rested for 30 min, sheeted and molded, placed in tins, and baked. The loaves are evaluated the following day for volume, shape, crust color, crumb structure and crumb texture.

Conclusion. Wheat the second largest cereal is used in all most all the countries in the world. Wheat milling is an ancient technology, where the stone rollers were used using either human /animal energy or through water or wind energy. During the 1850's the porcelain or steel rollers were used for milling leading its way for the development of modern milling technology. Today milling technology produces different types of flour based on the requirements for the production of various products. The products of wheat may vary from roti to bread, cookies, cakes and fried snacks to pasta.

Various types of tests are developed using a number of highly automated equipment's to test the quality of the flour to design new types of wheat based products.

Table 1 Composition of Endosperm, Germ and Bran of Wheat

Parameters	Endosperm (%)	Germ (%)	Bran (%)
Moisture	14.0	11.7	13.2
Protein	9.6	28.5	14.4
Fat	1.4	10.4	4.7
Ash	0.7	4.5	6.3
Carbohydrate	74.3	44.9	61.4
Starch	71.0	14.0	8.6
Hemicellulose	1.8	6.8	26.2
Sugars	1.1	16.2	4.6
Cellulose	0.2	7.2	21.4
Total carbohydrate	74.1	44.5	60.8

Pericarp

Bran

Wheat

Kernel

White Flour

Germ

Seed Coat

Seed

Aleurone

Endosperm

Starchy Endosperm

Embryo

Scutellum

Embryonic Axis

Epiblast

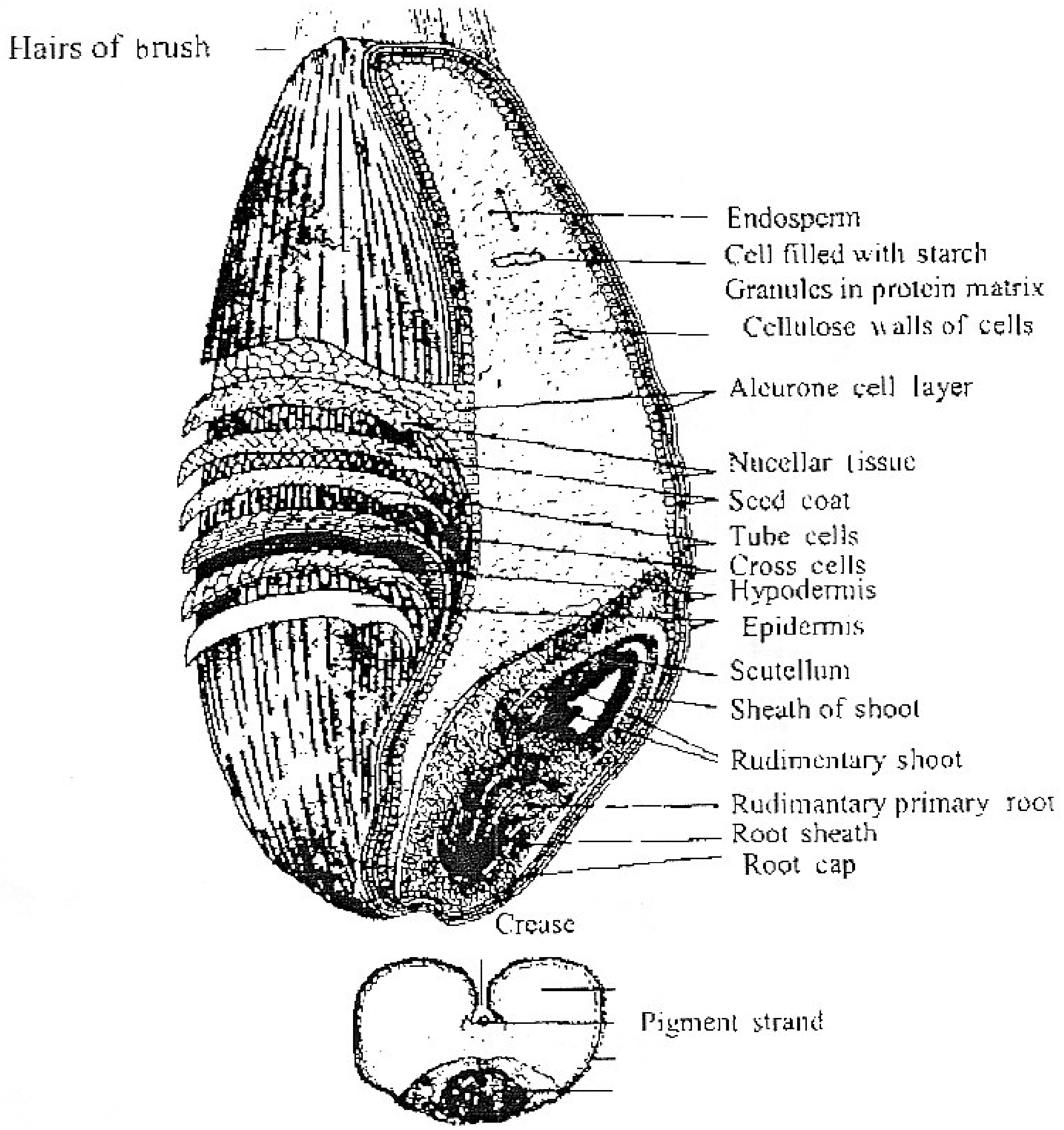

Fig. 1 Diagrammatic illustrations of wheat structure. (From Lasztity, 1999.)