Milling Processes and Production Capacity in Roller Mills and Single Stage Mills

1. Wheat Milling

Milling Process – Rollermills

In rollermills, milling consists of three basic activities:

1. *Grinding:* breaks the grain and parts of the grain with some separation of the individual parts of the grain.
2. *Sieving:* classifies mixtures of grain particles of different sizes into fractions of narrower particle size ranges.
3. *Purifying:* separates mixtures of bran and endosperm particles using air currents and sieves.

Gradual Reduction Process

The milling process for rollermills is defined as a gradual reduction process. This breaks down the grain in a series of grinding stages using a succession of grinding rolls of different types. Each grinding stage produces a blend of coarse, medium and fine fractions including flour. These mixtures are then sieved and purified to allow for a good separation of bran and endosperm. The Gradual Reduction Process consists of two main systems that are interconnected: These are:

Break System

The Break System consists of 4 or 5 rollermill stages. The rolls are corrugated and set in pairs. The objective of the break system is to remove as much of the endosperm from the wheat berry and to separate the endosperm particles from the bran and germ particles using sifters and purifiers.

Reduction System

The Reduction System consists of 8 to 16 grinding stages depending upon the type of wheat to be milled. The objective of the reduction system is to grind the endosperm into finer particles producing flour using rollermills and sifters.

Flour Collection System

Flour is produced at every grinding stage; each flour is known as a “flour stream”. The proportion of each flour stream as a percentage of the total flour produced will vary considerably depending upon its origin in the mill. For example most of the flour originates from the first few grinding stages at the start of the reduction system.

All the individual flour streams are transferred from the sifters through spouts connected to a flour collection conveyor. The flour collection conveyor is a screw conveyor that blends all the individual flour streams together producing the final flour. In some mills there may be 2 or 3 flour collection conveyors depending upon the commercial requirements and the marketplace.

Milling Process – Single Stage Milling

Unlike the rollermill process, single stage milling is a rapid single milling method that converts wheat, maize and any other cereal grain into flour made up of all the components of the grain berry. In some cases the grain may be dehulled (maize) or decorticated (sorghum) prior to milling.

The equipment for these mills is very simple and can be powered by hand, water, animals, electricity or diesel engine. The mills can be of the following types:

Stone mill
The grain passes between a pair of stones, one of which is turning while the other is stationary. The stones may be vertical or horizontal.

Hammermill

Hammermills consist of swiveled metal blades that grind the grain by smashing it against a metal screen. These mills run at very high speed and the fine meal is forced through the screen by air due to the high speed of the hammers.

Plate mill

The grain is passed through a pair of metal plates one of which is running and the other is stationary. The plates are usually in the vertical position.

Pin mill

The grain is passed through a pair of plates which have pins protruding from them. One plate runs against a stationary plate. The fine meal is then forces through the screen by air due to the high speed of rotation of the plates.

Milling Products

The following table illustrates the types of products produced from the different types of milling process.

Table x Basic Mill Products

Milling Process	Grain Types	Milled Products
Rollermill	Wheat Maize Rye	White Flours Whole Grain Flours Bran Germ
Single Stage	All cereals	Whole Grain Flours

Production Capacity

Rollermills

By convention *production capacity* is defined as the amount of wheat that can be processed in a rollermill in a 24 hour period. It is usually expressed in terms of Metric Tonnes (MT) of wheat that can be cleaned and ground in 24 hours assuming that the mill operates for a full 24 hours. In many countries flour mills do not always operate for 24 hours per day but will operate between 8 to 24 hours a day depending upon power availability and market conditions. Some mills may report production capacity as the amount of flour that can be produced in 24 hours. These figures are typically 20% lower than the amount of wheat that can be processed. Typical production capacities range from 40 to 500 MT. Flour production can be estimated based on the Extraction Rate (see below).

Single stage mills

These mills run at much lower capacities than rollermills. These mills run for 8 to 12 hours per day. The milling capacities range from 0.5 to 1.5 MT per hour depending upon size and power source and availability.

Extraction Rate

Extraction Rate is defined as the amount of flour produced by weight from a known weight of wheat. This is known as “flour yield” or percentage extraction rate. This is sometimes calculated from dirty wheat as received and sometimes from cleaned, tempered wheat. The latter can produce slightly higher values. The source of white flour in wheat is the endosperm, which represents about 82% of the total wheat berry (the germ is about 2% and bran is about 16%). Therefore the theoretical maximum amount of white flour that can be obtained is 82%. These figures differ depending on the size of the wheat kernel, with the larger, plumper kernels capable of producing more flour. In actual practice the maximum amount of white flour is about 80%.

White and brown flours

With increasing extraction the flour contains higher amounts of bran, alerone (the layer between the endosperm and the bran) and germ fractions along with increased levels of most micronutrients. Flours with extraction rates above roughly 83% are considered to be *high extraction flours*. If little or no bran or germ is removed then the resulting flour is considered to be whole wheat flour. Flours with extraction rates below 83% are *white flours* while *brown flours* have extractions between 83% and 95%.

Ash content

The most common and sensitive method used for assessing the degree to which wheat has been refined into flour is its *ash content*. This is measured by incinerating a weighed sample of flour in a furnace at a very high temperature for a set period of time. The resultant ash is weighed and expressed as a percentage of the flour weight. Ash content is a measure of mineral matter in the grain and flour. The bran coat contains about 5% ash compared to 0.3% for pure endosperm.

Therefore ash content is a measure of bran contamination in white flour and hence extraction rate. The higher the extraction, the higher the ash content, the greater the bran contamination and the higher the mineral content in that flour.

Table xx Extraction Rates and Ash Contents of Different Grades of Flours

Flour Type	**Ash Content %**	**Extraction Rate**
Top Patent	0.40	50%
Patent	0.50	70-75%
Straight Grade	0.55-0.75	78-83%
High Extraction (Brown)	0.75-1.10	83-95%
Whole Wheat flour	1.1-1.5	95-100%

Maize (Corn) Milling

White and yellow maize can be milled in two different ways, dry milling and wet milling. Only dry milling is included here since wet milled maize products are not normally fortified. Maize can be milled using both a rollermill and a single stage process (as described for wheat milling).

Rollermilling of Maize

The rollermilling process for maize is similar to that of wheat with the following exceptions:

- The maize kernels have to be de-germed and de-hulled prior to grinding on rollermills.
- The maize is transformed into grits (endosperm particles larger than flour) with the amount of flour minimized by the milling process.

Maize milling produces a number of products differing in particle size, composition and application. Many of these products are not suitable for mass fortification as they are used for non-food products (wallpaper paste, corn oil extraction, brewing) or special use foods (snacks, breakfast cereals, ingredients, fillers).

Only those maize grits and meal products intended for direct food consumption are covered here.

Single Stage Milling

Single stage maize mills are found extensively throughout Africa and Central America. These are usually stone mills, hammer mills or plate mills. These mills are used in rural and peri-urban areas. The maize is produced by subsistence farmers who take the grain to the mill for processing. The miller takes cash payment or withholds a portion of the finished flour as payment. The finished flours are whole grain maize flours or maize flour milled from de-hulled maize. In this case the maize is dehulled manually at the household level or with a separate dehulling machine at the mill and then ground into meal. In some parts of Africa and Central America the maize is soaked and then processed.

Maize Products and Food Uses

The milled maize products intended for direct human consumption may be made from white or yellow maize and may differ in particle size, extraction and whether or not the germ has been removed.

The following table shows the composition of maize meals available in South Africa. All but the unsifted products are intended to be fortified.

Table xx Maize Meals Produced in South Africa

Maize Meal Product Name	***Ash content target***	***Fat target***	***Extraction target***	***Percent of market***
Super	0.55 %	1.5%	63 %	36
Special	0.85 %	2.7%	79 %	36
Sifted	1.1 %	3.7%	89 %	12
Unsifted	**--**	**--**	~100%	