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DEPARTMENT OF AGRICULTURAL ENGINEERING

AI3601 POST- HARVEST TECHNOLOGY

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MILLING OF WHEAT

Introduction

Wheat is the one of the important cereal crop of the World, with an estimated annual production of 540 - 580 million metric tonnes. Wheat belongs to the genus *Triticum* of the grass family Gramineae. Common wheat (*Triticum aestivum*) and durum wheat (*Triticum durum*) are the two major wheat groups grown for food use now. Wheat is the most valuable of all food grains and is widely used in all its stages, from whole to finely milled and sifted. In the bakery, wheat flour is the most important ingredient, which provides bulk and structure to most bakery products, including breads, cakes, cookies, and pastries. Wheat is classified into two groups: hard and soft. Hard wheat is higher in protein compared to soft wheat. It yields stronger flour, which forms more elastic dough, and is better for bread making when strong elastic dough is essential for high leavened volume. Soft wheat is lower in protein, which forms weaker dough or batter, and is better for cake making.

Wheat Processing

Storage

Quality of wheat is to be preserved while moving from field to storage and subsequently to the processing mill. If not properly stored; insects, moisture damage, molds or other conditions may cause losses. Moisture content must be less than 20% before harvesting, and wheat is then carefully dried to moisture below 12.5%, a level which is regarded as safe for storage. The desired moisture content is achieved in kiln or in modern driers taking care of the temperature of grain does not exceed 50C.

Milling

The objective of wheat milling is to grind cleaned and tempered wheat by separating the outer husk from the internal endosperm. Early processing of wheat was accomplished by means of hand grinding, grinding stones, or a mortar and pestle. Later on wheat was milled between two circular millstones, one fixed and the other mobile and rotating. Recent technology of wheat milling involves metal cylinders or rollers for milling purposes.

Cleaning

Wheat received at mill may contain certain impurities entering from field, during storage and transportation, or accidentally. Frequently encountered impurities include: straws, chaff, sticks, weed seeds, other cereal grains, shrunken and broken kernels, infected kernels, mud, dust, stones, metal objects, etc. Wheat cleaning operation makes use of certain characteristics of impurities which are different from those of wheat e.g. size (length and width), shape, terminal velocity in the air currents, specific gravity, magnetic and electrostatic properties, colour, surface roughness, etc.

The grain is initially passed through a series of screens of selected apertures that removes matter either smaller or larger in size than the wheat kernel. Gross foreign material is removed over a set of sieves (rubble separator).

In gravity separator, impurities which are similar to wheat in size but different in specific gravity are separated out. Wheat grains are then moved on tilted screen, through which adjusted air currents are drawn. Heavier materials such as stones are separated and remain closer to screen, while lighter impurities and wheat floats down the screen.

After gravity separation, series of rotating discs separators remove impurities that are similar in diameter but different in shape from the wheat. This rotating discs with indentations pick-up only those wheat kernels that fit into the pockets and allow other grains such as oats, barley to pass through.

Dry scouring of wheat kernel removes any dirt adhering to it. In the scorer wheat kernel is bounced against a wall, which may be of a perforated sheet metal, a steel wire woven screen or any emery surface.

Magnetic separators separate foreign materials such as nails, pieces of metal that could damage equipments or generate spark, which could cause a dust explosion.

In final cleaning operation, wheat is washed by water. Wheat is immersed in water (0.5 - 1.0 lit per kg) and then conveyed by means of a worm to a centrifugal machine called whizzer, where it is vigorously agitated and spun dried. Washing of wheat removes crease dust.

Conditioning / Tempering

Conditioning of wheat is carried out primarily to improve the physical state of grain for milling. In conditioning moisture content of wheat kernel is adjusted. This includes heating and cooling of the grain for definite period of time, in order to obtain the desired moisture content and distribution. At this adjusted moisture level of wheat before milling, wheat endosperm becomes mellow and bran becomes tough. Bran that absorbs proper amount of moisture becomes elastic and will not splinter during grinding to contaminate the flour with fine particles, and thus flour becomes whiter in colour. The endosperm becomes mellower and more friable, thereby reducing the amount of power required to grind it.

Several methods are employed to condition the wheat. Heating the wheat, application of warm water, application of live steam, or just intensive mixing of wheat and water are some of the methods used to increase the amount and rate of water penetration into kernel.

Three factors affect the rate and level of water penetration into the kernel: temperature, amount of water (% moisture content) and time. The ideal water and wheat temperature for tempering condition is 25C. Higher temperature will increase the rate of penetration into the kernel. Temperature above 50C will change endosperm starch and protein characteristics.

Typical moisture contents of tempered wheat and tempering times are as follow:

Table Typical moisture contents of tempered wheat and tempering times

Type of wheat	Optimum moisture content of tempered wheat	Tempering time (Hrs)
Hard spring wheat	16 - 17%	36
Hard red winter wheat	15.5 - 16.5%	24
Soft wheat	14.5 - 15.5%	10
Durum wheat	16 - 17.5%	6

Milling / Separation of flour

Objective of wheat milling is to separate the branny cover and germ of the wheat kernel from the endosperm **Fig**

Wheat flour milling is a process that consists of controlled breaking, reduction and separation, Wheat flour milling involves three basic processes:

i). Grinding: Fragmenting the grain or its parts
ii). Sieving: Classifying mixtures of particles based on its particle size
iii). Purifying: Separating bran from endosperm particles based on their terminal velocity, by means of air currents.

Grinding of the wheat occurs between two cast rolls (break rolls) that rotates against each other. These rollers are fluted and they are not in contact with each other. The upper roller rotates two and a half time for each rotation of the lower one. Hence, the grain is engaged between fluted serrations of the rolls and broken or cut by the faster roll as it is held back by the slower roll. This initial stage in milling process is referred as breaks. The breaks are used in the grinding steps to separate the bran, germ and endosperm from each other. The grist coming out from the rolls is sifted through a plansifters. The plansifter is a machine consisting of a vertical nest of horizontal sieves, the whole assembly gyrating in a horizontal plane. A single plansifter consist of four or five different mesh sizes may yield five or six fractions of different particle size.

The series of break rolls and sieves converts the grain into semolina, which is small granule made up of endosperm. The outer husk is collected separately as bran. The semolina is separated into three grades: fine, medium, coarse in an operation called gradual reduction system. Here the rolls are smooth and one rotates only one and a quarter times for each rotation of the other.

These three streams are then put through purifiers. Purifier consists of a long, narrow, sieve set. The sieves become coarser progressively in size of mesh from head to tail. The sieve section is connected to a fan and the air is drawn up through each sieve section to draw off branny particles.

The number of parts of flour by weight produced per 100 parts of wheat milled is known as the flour yield, or percentage extraction rate. The wheat grain contains 82% of white starchy endosperm, but it is never possible to separate it out fully from the bran. Extraction rates of different flours are as follow:

Table Extraction rates of different flours

Sr. No.	Flour	Extraction rate (%)
1	Whole meal flour	95
2	Brownish flour	85
3	Creamy flour	80
4	White flour	70

Air Classification of Specialty Flour

Air classification of flour is used where there is a demand for extremely precise specification of granulation and protein content of flour. Flour with a narrow range of particle size has the advantage of increasing the tolerance of oven temperature and water absorption during the baking of cakes. Commercial flour particles granulation is between 0-150m. A flour fraction of 1-17 m contains a high level of protein. A flour fraction of 17-40 m will usually be marked as to its higher starch content and lower protein level. It is not practical to separate particles of less than 73 m with conventional sieves. Accordingly, particles are segregated by air using differences in particle shape, specific gravity and size.

Milling By-Products

The by-products from wheat milling process are known as wheat feed. They comprise bran, the coarse residue from break grinds, fine wheat feed, accumulated particles from the purifiers and reduction grinding. Bran and fine wheat feed are used in compound animal feeds.

Pulses

G

rocessing of pulses is of primary importance in improving their nutritive value. The processing methods used are soaking, g
s, cooking and fermentation.

king in water is the first step in most methods of preparing pulses for consumption. As indicated above, soaking reduces the
des of the raffinose family. Soaking also reduces the amount of phytic acid in pulses.

: Germination improves the nutritive value of food pulses. The ascorbic acid content of pulses increases manifold after 48 h
Germinated and sprouted pulses have been used to prevent and cure scurvy. The riboflavin, niacin, choline and biotin conten
e during germination. The germination process reduces and/or eliminates most of the antinutritional and toxic factors in sev

n: A simple method is to soak the seeds for a short time in water; the husk takes up more water than the seeds and may be ea
rubbing while still moist. In the alternative, the soaked grains may be dried and the husk removed by pounding and winnowi
he husk easier to separate. Roasted legumes like those of Bengal gram and peas are widely used in India.

oking destroys the enzyme inhibitors and thus improve the nutritional quality of food pulses. Cooking also improves the pal

n: The processing of food pulses by fermentation increases their digestibility, palatability and nutritive value. Fermentation
availability of essential amino acids and, thus, the nutritional quality of protein of the blend. In general, the nutritive value o
ted foods has been shown to be higher than their raw counterparts.

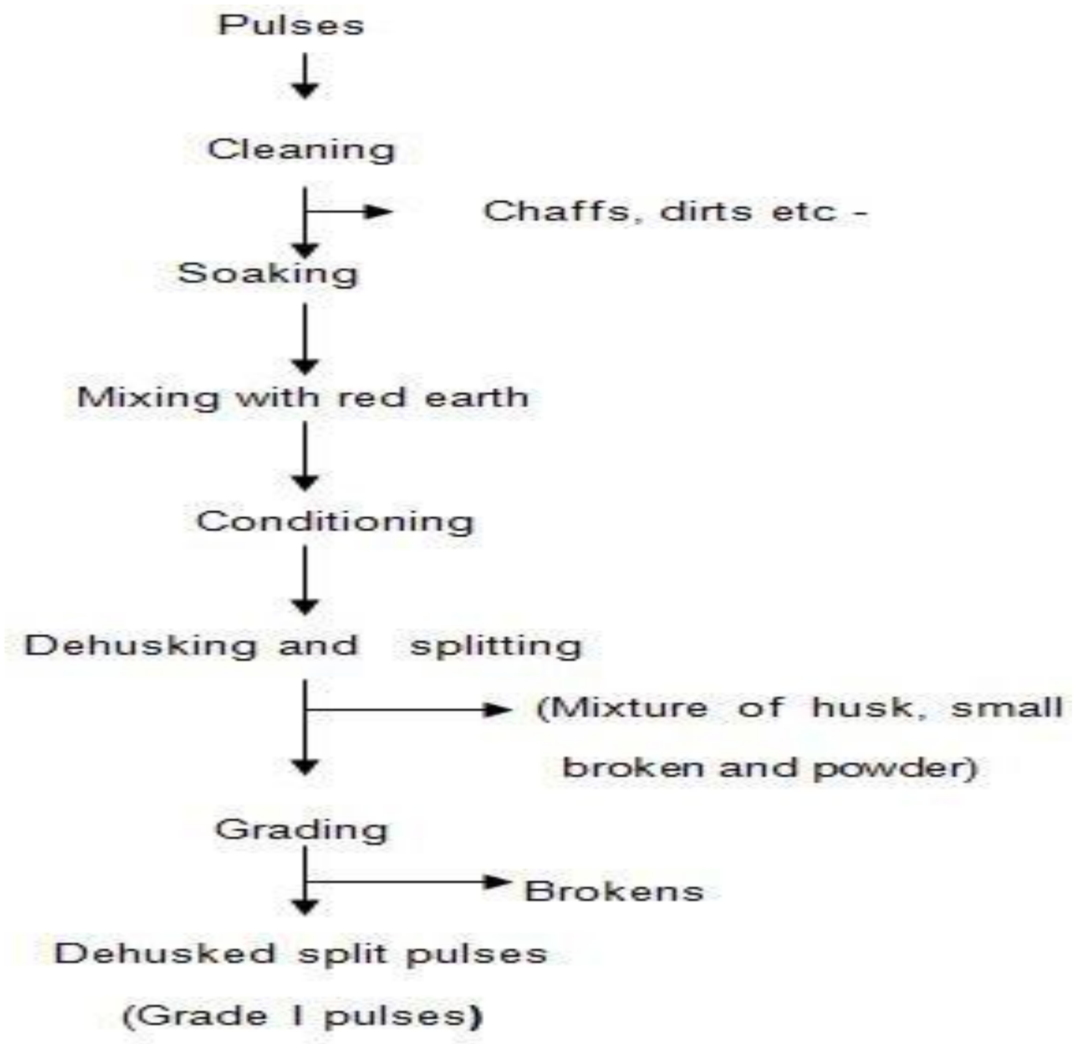
: Pulses are usually converted into Dhal by decutilating and splitting. Both dry and wet milling processes are employed. By
emery rollers are used for dehusking and burr grinders for splitting. Decuticling is seldom complete in single pass requiring
ass producing 1.5 to 2% fines reducing recovery of dal.

es in dhal milling are cleaning, dehusking, splitting, separation and bagging. Major variation is involved with dehusking pro
ahar, urad, moong and lentil are difficult to dehusk as a result repeated operations by dehusking rollers are required. Rewett
e to loosen portions of husk sticking after repeated rolling. Linseed oil is used to impart shine or better appeal to the milled d

of the outer husk and splitting the grain into two equal halves is known as milling of pulses. To facilitate dehusking and split
te wetting and drying method is used. In India trading milling methods produce dehusked split pulses. Loosening of husk by
is insufficient in traditional methods. To obtain complete dehusking of the grains a large number of abrasive force is applied

h losses occur in the form of brokens and powder. Yield of split & pulses in traditional mills are only 65 to 75% due to the a
32 to 85% potential yield.

lses : In India, there are two conventional pulses milling methods ; wet milling method and dry milling method. The latter i
sed in commercial mills.



MILLETS: TYPES AND PROCESSING

Introduction

The grasses known collectively as millets are a set of highly variable, small seeded plant species indigenous to many areas of the world. Millets are of value especially in semiarid regions because of their short growing season and higher productivity under heat and drought conditions. Pearl millet is the most widely grown millet and is a very important crop in India and parts of Africa. Finger millet is popular in East Africa and India. Foxtail and Proso millets are cultivated primarily in the Near East and China. Proso millet is also widely cultivated in the Russia Federation. Fonio and teff are grown in West Africa and Ethiopia, respectively. Most commonly grown millets with their common name is listed in Table 8.1. The millets originated primarily in East and West Africa, Eurasia, India and China from wild seed stock. Pear millet is one of the earliest domesticated millets; carbonized grains have been found in sub-Saharan and West African sites inhabited 4000-5000 years ago.

Structural and Physical Properties

Kernel characteristics of the various millets are extremely diverse. The millets can be divided into two types of seeds: utricles and caryopses. In the utricle, the pericarp surrounds the seed like a sac but is attached to the seed at only one point. Finger millet, proso and foxtail millets are utricles. In these millets, the pericarp usually breaks away from the seed coat or testa, which is well developed, thick and forms a strong barrier over the endosperm. In a caryopsis, the pericarp is completely fused to the seeds. Pearl millet, fonio and teff are caryopses. For pearl millet, the kernels are composed of the pericarp, endosperm and germ, which comprise 8.4, 75.1 and 16.5% of the total kernel weight, respectively.

The endosperm comprises the majority of the kernel weight for all millets. There are four structural parts of the endosperm: the aleurone layer and the peripheral, corneous and floury endosperm areas (Fig. 8.1). All millets have a single layer aleurone that completely encircles the endosperm. The aleurone cells are rectangular with thick cell walls, and they contain protein, oil, minerals and enzymes. The peripheral corneous and floury endosperm areas are beneath the aleurone, in that order.

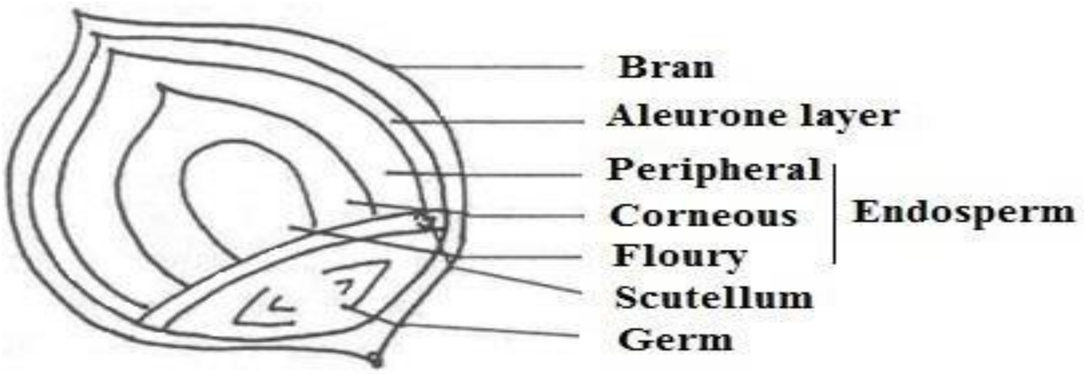


Fig. Structure of millet

Composition of millets

The mean values and variations in proximate composition of differnet types of millets are presented in Table 8.2.

Table Common and scientific name of major types of millets

Scientific Name	Common Name	Growing Areas
Pennisetum glaucum *P. americanum* *P. typhoiidesPanicum milaceum*	Pearl millet	Africa, India
Eleusine coracana	Finger millet	Africa, India, China
Setaria italica	Foxtail millet	China, Near East, Europe
Digitaria exilis *D. iburua*	Fonio	West and North Africa
Panicum sumatrense *P. psilopdium*	Little millet	India, Nepal, Burma
Eragrostis tef *E. abyssinica*	Teff	East Africa, Ethiopia
Paspalum scrobiculatum *P. commersoni*	Kodo millet	Southern Asia
Echinochloa crusgalli *E. utilis* *E.frumentacea* *E. colona*	Japanese milllet	Asia

Table Proximate composition of millets

Millet	Protein(%)	Fat, Ether extract (%)	Crude fiber (%)	Ash (%)	NFE (%)	Starch (%)
Pearl millet	14.5	5.1	2.0	2.0	76.4	71.6
Finger millet	8.0	1.5	3.0	3.0	84.5	59.0
Proso	13.4	9.7	6.3	4.2	69.4	57.1
Japanese millet	11.8	4.9	14.3	4.9	64.1	60.3
Foxtail millet	11.7	3.9	7.0	3.0	74.2	55.1
Kodo	10.4	3.7	9.7	3.6	72.6	72.0
Tef	10.9	2.4	2.4	2.2	82.1	73.1
Fonio	8.7	2.8	8.0	3.8	76.7	61.0

All values are expressed on dry matter basis.

Protein conversion factor=N X 6.25.

NFE=Nitrogen-free extract.

Food Utilization

Millets have been utilized for human food for prehistoric times. In India, virtually all of the pearl millet and most of the finger millet is directly consumed as human food. The most important use of pearl millet grain is in baking chapattis or rotis. Millet grain is also used for production of rice-like products and porridges. Pearl millet is also used to produce malt and alcoholic beverages. Millet flour has been successfully incorporated into cutlets, pakoras, weaning foods and biscuits.

Postharvest Processing

Storage

Millets are harvested, dried and stored intact in storage bins. Usually, the millet heads are pounded in a mortar and pestle, winnowed and the grains required for daily consumption is further processed (dehulled and ground) in the mortar and pestle as needed. Millets are traditionally stored in clay pots or raised huts. Millets have reputation of being less susceptible to the insect attack than other grains. This is due to small size of millet grains. The another reason is that they are commonly grown in semi arid areas of the world where the relative humidity is typically less than 40%, which is not optimum for many pests.

Milling

Milling separates the grain into three components, germ, endosperm and seed coat. Milling techniques practiced mostly depend on the end-use. Milling process starts with the cleaning of the grains, to remove unwanted impurities and broken grains, using vibratory sieves, aspirators and specific gravity separators. The cleaned grains are conditioned, by addition of water, to soften the endosperm. In developing countries, millets are normally decorticated and ground with mortar and pestle prior to use. Grinding stones are also used, followed by winnowing or washing at various stages of grinding to remove bran, coarse particles and fine particles. These milling techniques are labour intensive. In India, stone hand grinder, consisting of two round stones rotating horizontally against each other is used for grinding millets. Millets are also decorticated with abrasive discs in mechanical huller and ground into flour with attrition or hammer mills.

The endosperm is recovered in the form of grits, with the minimum production of flour. Yields of various fractions from the milling process are grit, 76.7; bran, 1.2; germ, 11; fiber, 10%.