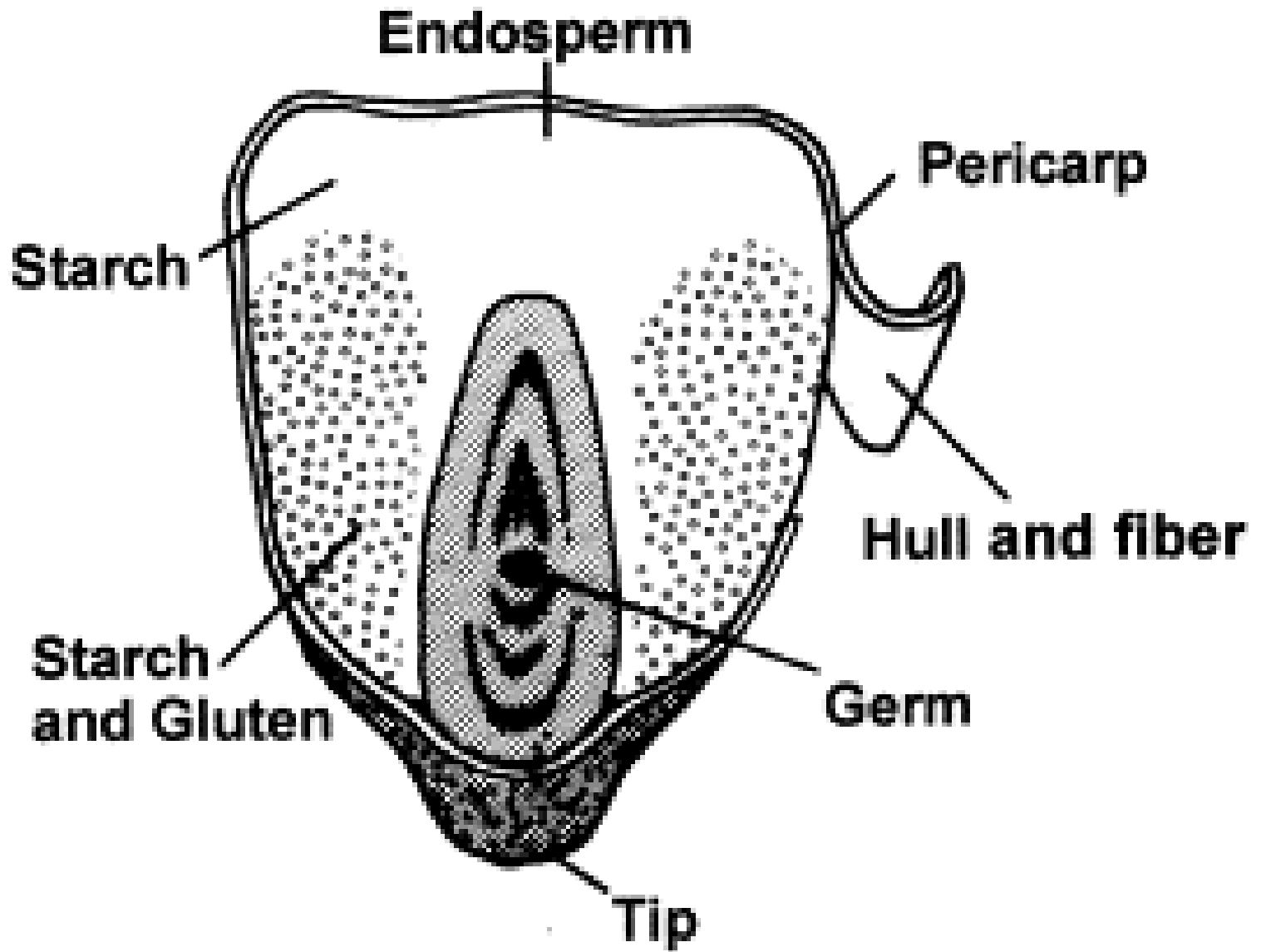


**PROCESSING
TECHNOLOGY OF CEREALS
ASFE 2201**

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CORN MILLING



INTRODUCTION

- ✓ Corn is one of the world's most versatile seed crops. Its botanical name is *Zea mays*. Corn is used as food and feed.
- ✓ Corn can be processed into various food and feed ingredients, industrial products and alcoholic beverages.
- ✓ There are two modern methods of milling of corns, **dry milling and wet milling**.
- ✓ Besides germ for corn oil extraction and husk and deoiled germ, etc..., for feed, grits (mainly used for the breakfast cereals) are the main products of corn dry milling whereas pure starch, germ and feed are the major products of wet milling.

CORN DRY MILLING

- ✓ Corn dry milling system can be divided into two groups : the traditional **non: degerming system and modern degerming system.**
- ✓ In the non degerming system, the **whole corn is ground** into meal of high fibre as well as high protein contents by a stone grinder without removing germ. After grinding certain amount of germ and hull can be removed from the meal by **sifting.**
- ✓ In the degerming system the corn is moistened with a little amount of water and tempered for moisture equilibration. After degerming the stock is dried, milled and classified into different products.
- ✓ The purpose of all dry degerming corn milling methods is to remove **hull, germ and tip cap** from the corn kernel as far as practicable and primarily produce corn grits with some meals and flours.
- ✓ The **germ** is then used for oil extraction and deoiled germ, hull, etc., are used as feed.
- ✓ The yield of endosperm products are about **70 per cent.**

TEMPERING-DEGERMING (T.D.) METHOD OF DRY MILLING:

The major objectives of this method are :

- (a) to remove essentially all germ and hull so that endosperm contains **as low fat and fibre** as possible,
- (b) to recover a maximum amount of the endosperm as large clean grits without any dark speck, and
- (c) to recover a maximum amount of germ as large and pure particles.

DESCRIPTION OF THE T.D SYSTEM

- 1) Cleaning of the corn
- 2) Conditioning of the corn by addition of control amount of moisture
- 3) Releasing hull, germ, and tip cap from the endosperm in a degermer.
- 4) Drying and cooling the degermer products obtained from the degermer.
- 5) Fractionating degermer stock by multistep milling through a series of machines namely roller mills, sifters, aspirators, gravity table separators, and purifiers to separate and recover the various products.
- 6) Drying of the products
- 7) Blending and packaging of products.

1. Cleaning of corn

- ✓ Thorough cleaning of corn is essential for the subsequent milling operations. Pieces of iron, etc., are removed by magnetic separators.
- ✓ Dry cleaners consisting of sieves and aspirators and sometimes a wet cleaner consisting of a washing destoning unit and a mechanical type dewatering unit, known as whizzer, are used for cleaning of corn.

2. Hydrothermal treatment / conditioning

- ✓ Predetermined amount of moisture is added to the corn in the form of cold or hot water or steam in one, two or three stages with appropriate tempering times after each stage.
- ✓ The tempering times (rest periods) vary according to the hydration methods. So also tempering temperatures vary from room temperature to about 50°C accordingly.
- ✓ The optimum moisture content for degerming in the Beall Degermer is 21-25%.
- ✓ Either cold or hot water is used for the addition of moisture. A little heat in the form of open steam is added as and when necessary.

3. Degerming

- ✓ The purpose of degerming is to remove hull, tip cap, and germ as far as practicable and leave the endosperm into large grits.
- ✓ However, the products from degermer consists of a mixture of kernel components, freed from each other to varying degrees, with the endosperm particles varying in sizes from grits to flour.
- ✓ The Beall Degermer consists of a **rotating cast iron conical roller mounted on a horizontal shaft in a conical cage.**
- ✓ Part of the cage is fitted with perforated screens and the remainder with plates having conical projections on its inner surface.
- ✓ The rotating cone has similar projections over most of its surface.
- ✓ The feed end of the cone has spiral corrugations to move the corn forward whereas the large end has corrugations in an opposite direction to retard the flow.

- ✓ The product leaves the unit in two streams.
- ✓ The major portions of the released **germ, husk and fines** as well as some of the grits are discharged through the perforated screens.
- ✓ Tail stock containing large amount of grits, escapes through an opening fitted with the large end of the cone. A hinged gate with an adjustable weight adjusts pressure inside the chamber and controls the flow of the stock.

4. **Drying and cooling of degermer stock**

- ✓ The degermer products are to be dried to 15 to 18 per cent moisture content for proper grinding and sifting.
- ✓ Generally rotary steam tube dryers are used for drying the product.
- ✓ The stock is heated to about 50°C.
- ✓ Counter flow or cross-flow rotary, vertical gravity or fluidized bed types of cooler can be used for cooling the dried products.

5. Rolling and Grading

- ✓ Recovery of various primary products is the next step. Further release of germ and husk from the endosperm products occurs during their gradual size reduction roller mills.
- ✓ The germ, husk and endosperm fragments are then separated by means of sifters, aspirators, specific gravity table separators or purifiers.
- ✓ Sifting is an important operation and is variously referred to as scalping, grading, classifying, or bolting depending upon the means used and purpose.
- ✓ Sifting is actually a size separation operation on sieves.
- ✓ Scalping is the coarse separation made on the product leaving a roller mill or degermer. Grading or classifying is the separation of a single stock (usually endosperm particles) into two or more groups according to particle size.
- ✓ Bolting is the removal of hull fragments from a corn meal or flour.

CORN WET MILLING

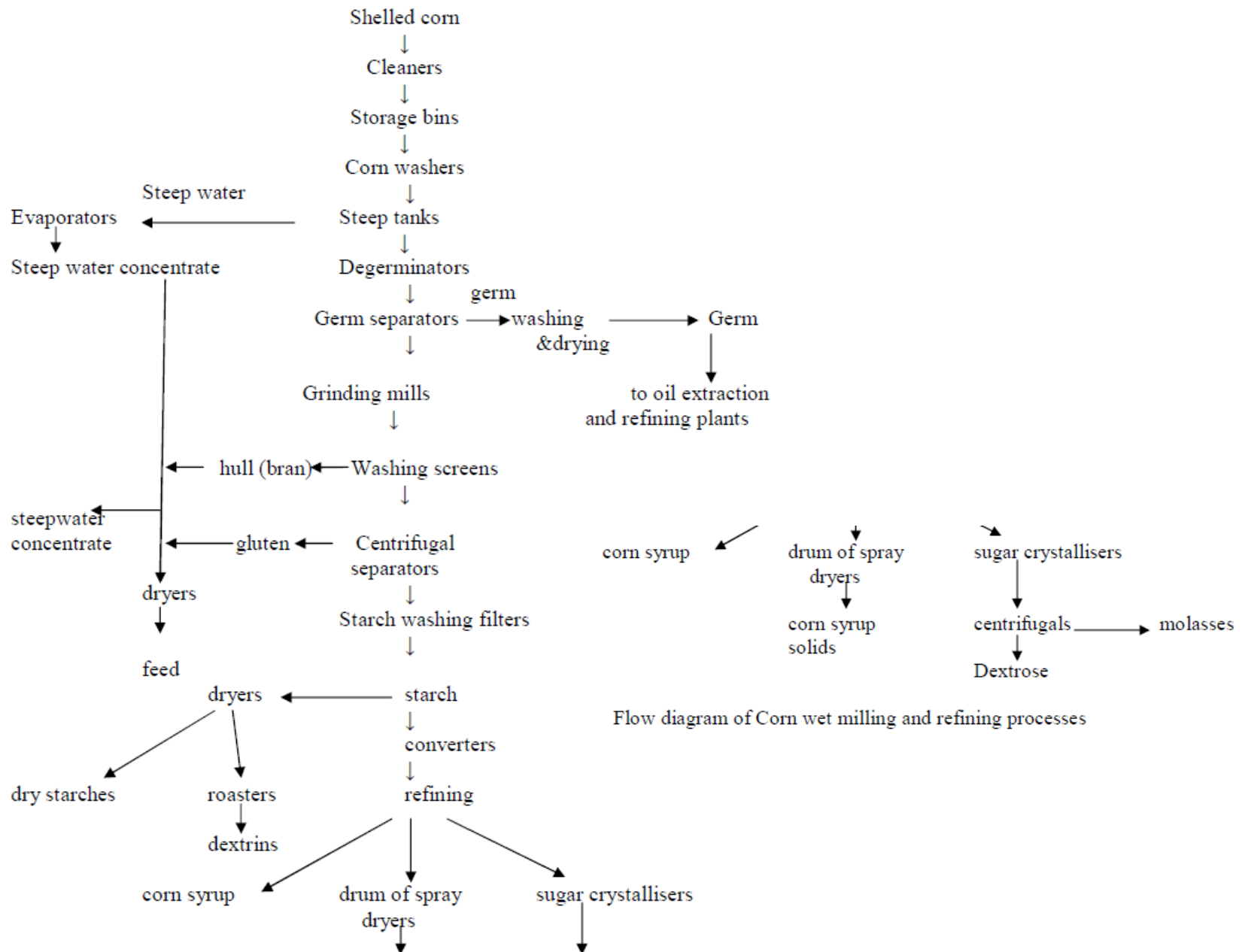
- ✓ Pure starch, pure germ and feed are the basic products of corn wet milling.
- ✓ But a few hundreds of byproducts can be produced from these three main products. A list of these byproducts with their uses is given in Table.

Table.: Corn Wet milling products

Product	Feed/food uses	Industrial uses
Germ oil and meal foods	Livestock	Soap, glycerine, leather dressing
Refined oil	Salad and table oils, cooking oils, margarine	Pharmaceuticals
Steep water	Yeast food	Phytic acid, inositol
Gluten and hulls	Livestock and poultry feed	
Starch	Corn starch, chewing gum, bakeries, baking powder, brewing confectionery	Textiles, laundry, paper and paper boxes, explosives, cosmetics, adhesives
Syrup	Bakery products, canned fruits, ice cream, confectionery, soft drinks, chewing gums, mixed syrups and jellies	Textiles, leather tanning, pharmaceuticals, tobacco
Sugar	Bakery products, pharmaceuticals, jams and jellies, ice cream, canned foods, confectionery	Rayon, tanning, fermentation, brewing, vinegar, carmel colour, fermentation products, tobacco.

- ✓ The raw corn for wet milling should contain 15-16 per cent moisture and it should be physically sound.
- ✓ Insect and pest infested, cracked and heat damaged corns (treated at temperature around 75°C during drying) are unsuitable for wet milling.
- ✓ The heat damaged corn affects the quality of oil extracted from its germ.
- ✓ Sufficient amount of moisture is added to the corn during steeping in the wet milling process in order to prepare the corn for subsequent degerming, grinding and separation operations.

The flow diagram of corn wet milling process



Flow diagram of Corn wet milling and refining processes

The wet milling process consists of the following steps :

(a) Cleaning, (b) soaking, (c). germ separation and recovery, (d) grinding and hull recovery, and (e) separation of starch and gluten.

a. Cleaning

- ✓ All impurities such as dust; chaff, cobs, stones; insect-infested grain and broken grain, and other foreign materials are removed from corn by screening and aspirating. The clean grains are conveyed to the storage bins.

b. Steeping

The major objectives of steeping are

- 1) To soften the kernel for grinding,
- 2) To facilitate separation of germ,
- 3) To facilitate separation of gluten from the starch granules,
- 4) To remove solubles, mainly from the germ.

- ✓ Water impregnated with SO_2 (i.e, acidulated water with H_2SO_3) is used for steeping.
- ✓ It helps in arresting certain fermentation during long steeping process.
- ✓ The steeping is carried out at about 50°C for a period varying from 28 to 48 hours in different plants.
- ✓ The steeped corn attains a moisture content of about 45 per cent.

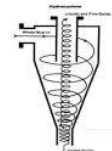
c. Germ Recovery

- ✓ The wet and softened corn kernels containing about **45 per cent moisture** are conveyed to the degerminating unit.
- ✓ This machine consisting of a metallic stationary plate and a rotating plate with projecting teeth is employed only for tearing the soft kernels apart and freeing the germs without grinding them.
- ✓ The pulpy mixture containing germs, husk, starch and gluten is passed through **hydroclones**, where the germ being lighter is separated from other heavier ingredients, by centrifugal force.
- ✓ Only modern starch plants employ hydroclones for germ separation.
- ✓ Otherwise the floatation method of germ separation is still in use in old types of mills.

Hydrocyclones

• Analogous devices for separating particles or solids from liquids are called hydrocyclones or hydroclones.

• A hydrocyclone is a device to classify, separate or sort particles in a liquid suspension based on the ratio of their specific gravity to fluid resistance. This ratio is high for dense bodies, separation by density is required) and coarse (where separation by size is required) particles, and low for light and fine particles. Hydrocyclones also find application in the separation of liquids of different densities.



d. Milling and Fibre Recovery

- ✓ After separation of germ and screening of the coarse particles, the mixture contains starch, gluten and hulls.
- ✓ Mainly endosperm and hull are then generally ground by either **traditional Burstone mill or modern entoletor impact mills** to release the rest of the starch.
- ✓ Material to be ground enters the machine through a spinning rotor and is thrown out with great force against the impactors at the periphery of the rotor and also against a stationary impactor resulting in considerable reduction in particle size.
- ✓ Here only the starch is readily released, with a very little size reduction of hulls.
- ✓ The milled slurry, containing the ground starch, gluten, and hulls, is passed through a series of hexagonal reels where the coarser hulls and fibres are removed.

e. Starch- Gluten separation

- ✓ In the modern process, the slurry containing starch and gluten is concentrated and then the lighter gluten particles are separated from the relatively heavier starch particles by the centrifugal force in high speed centrifuges.
- ✓ The **centrifuging** of starch is carried out in two stages.
- ✓ In many modern plants, the second stage of centrifugation is performed by a number of hydroclone type of equipments.
- ✓ The starch obtained from the second stage of separation is filtered and then dried to produce dry starches.

PRODUCTS OF CORN MILLING

1. Degerminated flour:

- ✓ This represents about 70 per cent extraction.
- ✓ The degerminated flour consists mostly of the endosperm and has **low content of B-vitamins.**
- ✓ It is used by brewers as a starch medium for the action of barley malt in the preparation of wort for the production of beer.

2. Germ:

- ✓ Corn-germ contains about 21 .0 per cent proteins and 32 per cent fat. Since the germ constitutes about 13 per cent of the grain, it is an important source of proteins and fat.
- ✓ The oil can be extracted by solvent extraction and the residual protein-rich (about 30 per cent protein) corn germ flour can be incorporated in weaning foods.