### Products of Corn

#### Cornstarch

**Industrial Uses**
- Abrasive paper and cloth
- Adhesives (glues, mucilages, gums, etc.)
- Batteries, dry cell
- Binder or binding agents
- Board (corrugating, laminating, solid fiberboard, cardboard)
- Boiler compounds
- Bookbinding
- Briquettes
- Ceramics (as clay binder)
- Chemicals Cleaners, detergents
- Coatings on wood, metal and paper
- Color carrier (in paper and textile printing)
- Cord polishing, sizing
- Cork products
- Crayon and chalk (as a binder)
- Dispensing and standardizing agent
- Dressing, surgical
- Dyes (as a bodying agent, carrier diluent, etc.)
- Fermentation processes
- Fiberglass size
- Fireworks
- Insecticide powders
- Insulating material (glass wool, rock wool, etc.)
- Lubricating agents
- Oilcloth
- Oil-well drilling (drilling mud)
- Ore refining (electrolytic reduction process, flotation process, etc.)
- Paints (cleaning compounds, cold-water and latex paints, poster lacquers, etc.)
- Paper and paper products manufacture
- Plastics (molded)
- Plywood (interior)
- Printing
- Protective colloids (emulsions)
- Textiles (warp sizing and finishing)
- Tile, ceiling
- Tires, rubber
- Wallboard and wallpaper
- Water recovery, industrial

#### Corn Syrup

**Industrial Uses**
- Adhesives (plasticizing agent)
- Chemicals
- Dyes and inks
- Explosives
- Leather tanning (chrome process)
- Metal plating
- Paper, glassine and parchment
- Plasticizer
- Polish, shoe
- Rayon (viscose process)
- Textiles, for finishing
- Theatrical makeup
- Tobacco and tobacco products

### Food, Drug Uses;

**Liquid or dried form**
- Baby foods
- Bakery products (bread, rolls, biscuits, doughnuts, pies, cakes, cookies, pretzels, etc.)
- Beverages, brewed (beer, ale, etc.)
- Beverages, carbonated
- Breakfast foods
- Catsup, chili sauce, tomato sauce
- Cereals, prepared
- Cheese spreads and foods
- Chewing gum
- Chocolate products
- Coffee whiteners
- Condensed milk, sweetened
- Confectionery
- Cordials and liqueurs
- Desserts
- Eggs, frozen or dried
- Extracts and flavors
- Frostings and icings
- Fruit butters and juices
- Fruit drinks
- Fruits (canned, candied, fillings, frozen, etc.)
- Ice cream, water ices and sherbets
- Jams, jellies, marmalades and preserves
- Licorice
- Malted products
- Marshmallows and related products
- Meat products (sausage, etc.)
- Medicinal preparations (drugs, pharmaceuticals)
- Mixes, prepared (cakes, infant foods, pie fillings, pudding, powders, ice cream, etc.)
- Peanut butter
- Pickles and pickle products
- Salad dressing
- Sauces (seasoning, specialty, etc.)

#### Industrial Uses

- Acids, commercial (lactic, acetic, gluconic, etc.)
- Adhesives
- Amino acids
- Chemicals (calcium, lactate, sodium lactate, etc.)
- Citric
- Dyes
- Electroplating and galvanizing
- Enzymes
- Lactic acid polymers
- Leather tanning
- Lysine
- Mannitol
- Paper manufacturing
- Rubber (cold process)
- Sizing materials
- Sorbitol
- Textiles, dyeing and finishing
- Threonine
- Tryptophan

#### Food, Drug Uses

- Antibiotics
- Baby foods
- Bakery products (biscuits, bread, crackers, fillings, icings, macaroons, pretzels, cookies, crackers, wafers, etc.)
- Beverages, brewed (beer, ale, etc.)
- Beverages, carbonated
- Breakfast foods
- Caramel color
- Cheese foods and spreads
- Chewing gum
- Chocolate products
- Citric acid
- Citrus juices
- Coloring, pure food mix
- Condensed milk
- Confectionery
- Cordials, liqueurs and brandy
- Cream, frozen
- Dairy products
- Desserts
- Dietetic preparations
- Distillation products
- Doughnuts (cake, yeast)
- Drugs (fermentation process)
- Eggs, frozen or dried
- Fish, pickled
- Flavoring extracts
- Food acids (citric, etc.)
- Fruit juices
- Fruits and vegetables (canned)
- Fruits (candied, glace, frozen)
# Products of Corn

| Chewing gum | Seafood, frozen | Gelatin desserts |
| Chocolates drink | Soups, dehydrated | Ice cream, water ices and sherbets |
| Confectionery | Syrups (table, chocolate, cocoa, fruit, medicinal, soda fountain, cordials, etc.) | Infant and invalid feeding |
| Cosmetics | Toppings | Jams, jellies, marmalades and preserves |
| Desserts (puddings, custards, etc.) | Vinegar | Lactic acid |
| Drugs and pharmaceuticals | | Meat products (bacon, bologna, hams, sausage, frankfurters, mincemeat) |
| Flours, prepared (including prepared mixes) | High Fructose Corn Syrup | Medicinal preparations and intravenous injections, pills, tablets, drugs, etc. |
| Food and drug coatings | Food Uses | prepared (cake, icings and frosting, infant foods, pie fillings, toppings, etc.) |
| Meat products | Bakery products | Peanut butter |
| Mixes, prepared (pancake, waffle, cake, candy, etc.) | Canned fruits | Peas, canned |
| Mustard, prepared | Canned juices | Pectin, fruit |
| Pie filling | Condiments | Pickles and pickle products |
| Precooked frozen meals | Confectionery products | Prepared mixes |
| Salad dressing | Frozen desserts | Powders (ice cream, prepared dessert, pudding, summer drink, powders, etc.) |
| Soaps and cleaners | Jams, jellies and preserves | Sauces (catsup, tomato, etc.) |
| Soup | Soft drinks | Seasoning mixes, dry |
| Sugar, powdered | Wine | Sorbitol (in candies, toothpaste, etc.) |
| Vegetables, canned | Yeast | Soaps, dehydrated |
| Dextrins | | Spices and mustard preparations |
| Industrial Uses | Maltodextrins | Syrups (table, fountain, medicinal, etc.) |
| Adhesives (glues, pastes, mucilages, gums) | Food Uses | Vinegar |
| Bookbinding | Bakery mixes | Wine |
| Briquettes | Beverage powders | Xanthan gums |
| Candles | Condiments | Yeast |
| Ceramics | Dehydrated foods | | Hydrol |
| Cord polishing | Dry soup mixes | Corn-sugar molasses |
| Core binder (castings, molds, etc.) | Gum confections | Leather tanning |
| Cork products | Icings and glazes | Organic acids |
| Crayon and chalk (as a binder) | Instant tea | Organic solvents |
| Dyes (dry, cake, etc.) | Instant breakfast foods | Tobacco |
| Envelopes | Low calorie sweeteners | | Ethanol |
| Fireworks | Marshmallows | Alcoholic beverages |
| Inks, printing | Nougats | Industrial alcohol |
| Insecticides | Pan coatings | Octane enhancer |
| Insulation, fiberglass | Sauce and gravy mixes | Oxygenate in motor fuels |
| Labels | Snack foods | | Personal care products |
| Leather | | Mouthwash |
| Linoleum | | Toothpaste |
| Magazines | | |
Co-Products of Corn

<table>
<thead>
<tr>
<th>SOLUBLES</th>
<th>GLUTEN AND HULLS</th>
<th>GERM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steepwater</td>
<td>Steepwater for Feed</td>
<td><strong>Corn Oil</strong></td>
</tr>
<tr>
<td>Antibiotics</td>
<td>Gluten Feed and Meal</td>
<td><strong>Corn Oil, Refined</strong></td>
</tr>
<tr>
<td>Chemicals</td>
<td>Oil Meal</td>
<td><strong>Food, Drug Uses</strong></td>
</tr>
<tr>
<td>Pharmaceuticals</td>
<td>Products Used by Livestock,</td>
<td>Carriers for vitamins and other</td>
</tr>
<tr>
<td>Yeast</td>
<td>Poultry and Dairy</td>
<td>medicinal preparations in capsule form</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cooking oil</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Margarine</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mayonnaise</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Potato chips</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Salad dressing</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sauces, seasoning</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Shortening</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Soups</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Corn Oil and Free</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Fatty Acids</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Industrial Uses</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Chemicals and insecticides</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lecithin (for pharmaceuticals,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>cosmetics, linoleum, printing inks, etc.)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Paint and varnish</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rubber substitutes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rust preventative (surface coatings)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Soap</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Soluble oil (leather and tanning use)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Textiles</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Other Uses</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Amino acids</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fur cleaner</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Zein and other protein products</td>
</tr>
</tbody>
</table>
The Four Parts of a Kernel of Corn

THE ENDOSPERM
The endosperm is about 82 percent of the kernel’s dry weight and is the source of energy (starch) and protein for the germinating seed. There are two types of endosperm, soft and hard. In the hard endosperm, starch is packed tightly together. In the soft endosperm, the starch is loose. When corn dries in the field before harvest, the moisture loss causes the soft endosperm to collapse and form a dent in the top of the kernel, thus the term “dent” corn.

THE TIP CAP
The tip cap is the only area of the kernel not covered by the pericarp. It was the attachment point of the kernel to the cob.

THE PERICARP
The pericarp is the outer covering of the kernel that protects it from deterioration. It resists water and water vapor and is undesirable to insects and microorganisms.

THE GERM
The germ is the only living part of the corn kernel. It contains the essential genetic information, enzymes, vitamins and minerals for the kernel to grow into a corn plant. About 25 percent of the germ is corn oil. Corn oil is the most valuable part of the corn kernel. It is high in linoleic fatty acid (polyunsaturated fat) and has a bland taste.

<table>
<thead>
<tr>
<th>Corn Components</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Starch</td>
<td>61.0%</td>
</tr>
<tr>
<td>Feed</td>
<td>19.2%</td>
</tr>
<tr>
<td>Oil</td>
<td>3.8%</td>
</tr>
<tr>
<td>Water</td>
<td>16.0%</td>
</tr>
</tbody>
</table>
Connect The Dots

THE ENDOSPERM

The endosperm is about 82 percent of the kernel’s dry weight and is the source of energy (starch) and protein for the germinating seed. There are two types of endosperm, soft and hard. In the hard endosperm, starch is packed tightly together. In the soft endosperm, the starch is loose. When corn dries in the field before harvest, the moisture loss causes the soft endosperm to collapse and form a dent in the top of the kernel, thus the term “dent” corn.

THE PERICARP

The pericarp is the outer covering of the kernel that protects it from deterioration. It resists water and water vapor and is undesirable to insects and microorganisms.

THE TIP CAP

The tip cap is the only area of the kernel not covered by the pericarp. It was the attachment point of the kernel to the cob.

THE GERM

The germ is the only living part of the corn kernel. It contains the essential genetic information, enzymes, vitamins and minerals for the kernel to grow into a corn plant. About 25 percent of the germ is corn oil. Corn oil is the most valuable part of the corn kernel. It is
STARCH YOUR DAY RIGHT

Discovering the Starch in a Kernel of Corn:

1. Thaw a package of frozen corn and place in a bowl.

2. Crunch up the corn with a potato masher and cover with water.

3. Let stand about 24 hours.

4. Remove the corn from the bowl with a slotted spoon.

5. Allow the water to stand another 15 minutes.

6. Very slowly, gently pour the water through a piece of cheesecloth (allowing the starch to become trapped in the cloth).

7. You can feel and see the starch left in the cloth.

8. On a small portion of the cheesecloth place a drop of iodine. (If starch is present, the iodine changes from a reddish-brown to a blue-black.)

9. Allow the remainder of the cheesecloth to dry overnight.

10. In the morning, feel and taste the powder remaining on the cheesecloth.

11. You’ve made cornstarch!! (For experiments using cornstarch to make plastic see Unit 7, Lesson 4).
STARCH YOU DAY RIGHT

REFINING CORN

INTRODUCTION:

Corn refiners purchase shelled corn from farmers, corn elevators, or grain companies.

The first purpose of corn refining is to separate the four parts of the corn kernel:

1. The pericarp, the outer skin-like covering of the kernel.
2. The tip cap, the point where the kernel was attached to a corn cob.
3. The germ, the living part of a corn kernel containing genetic information and corn oil.
4. The endosperm, the protein and starch that make up over 80% of the mass of a kernel of corn.

The next purpose is to convert these parts into higher value products. Today the most important refined corn products are corn sweeteners, starch, oil, ethanol, and feed products.

STEP ONE: STEEPING

1. At the refinery, the corn is inspected and cleaned.
2. Then the corn is steeped, or soaked, in cool water for 30 to 40 hours.
3. The kernels double in size as they absorb the water.
4. As the kernels swell, the gluten (protein) bonds loosen and the starch is released.
5. The steep water is drained and used in animal feeds.
6. The corn is coarsely ground to separate the germ from the rest of the kernel.

STEP TWO: GERM SEPARATION

7. The coarsely ground corn is mixed with a small amount of water.
8. The mixture is moved to a germ separator that spins the corn germ out of the water.
9. The germ is screened to make sure no starch is present.
10. Corn oil is then extracted from the germ.
11. Any remaining germ is used in animal feeds.

**STEP THREE: STARCH AND GLUTEN SEPARATION**

12. After the germ has been removed from the coarsely ground corn, the rest of the kernel is ground again.

13. It is mixed with a little more water.

14. The fiber is screened out of the corn, so that only a starch-gluten mixture remains.

15. The gluten has a lower density than starch so a centrifuge is used to separate the two.

16. The gluten is a protein used in animal feed.

17. The starch can be dried and marketed as unmodified cornstarch, or

18. it can be modified into specialty corn starch, or

19. it can be converted into corn syrup or sugar, or

20. it can be processed into biodegradable plastics, or

21. it can be fermented and used in ethanol.

**RESULTS**

One bushel of shelled corn weighs about 56 pounds. Through refining, one bushel of corn can make:

- 31 pounds of starch,
- or
- 33 pounds of sweetener (enough to sweeten 324 cans of cola),
- or
- 2.5 gallons of ethanol fuel,
- PLUS
- 11 pounds of animal feed,
- and
- over 2.5 pounds of gluten meal,
- and
- 1.6 pounds of corn oil.

*Nothing is wasted!*
REFINING CORN

Fill-in-the-Blank:

One bushel of corn weighs approximately __ pounds.
(Answer: 56)

Corn oil is found in the _____ of the kernel.
(Answer: germ)

The endosperm contains _________________ and makes up over 80% of the mass of the corn kernel.
(Answer: gluten protein and starch)

The five most important refined corn products are ____________________________
(Answer: corn sweeteners, ethanol, starch, oil, and feed products.)

________________purchase shelled corn and separate the parts of a kernel of corn during the refining process.
(Answer: Corn refiners)

In the __________ process the corn is soaked in cool water for 30-40 hours, where the kernels swell to double their size.
(Answer: Steeping)

One bushel of corn can be refined into __ pounds of cornstarch plus __ pounds of animal feed, ___ pounds of gluten meal, and ___ pounds of corn oil.
(Answers: 31, 11, 2.5, 1.6)

The starch can be dried and marketed as unmodified or specialty cornstarch, or it can be converted into ________________
(Answer: corn syrup or sugar, biodegradable plastics or ethanol)


**BUBBLES**

1 cup dishwashing detergent  
3 cups water  
6 tablespoons white **corn syrup**

- Combine ingredients in a large jar or container, cover, and shake well.  
- Let the mixture settle for four hours.  
- Pour the bubble soap into a large pan or plastic tub.  
- After using the bubble soap, store it covered and labeled in the refrigerator.  
- Try to let the bubble soap come to room temperature before you use it again.  
- Enjoy!

- Make your own blower by cutting the bottom off a polyfoam cup, place the wide end in the soap, and blow from the cut end.  
- Or make a gigantic wand by bending a wire coat hanger into a circle.

**COOKED PLAYDOUGH**

*Mix together:*  
1 cup flour  
½ cup salt  
2 teaspoons cream of tartar

*Then add:*  
1 cup water  
1 tablespoon **corn oil**  
Food coloring*

*You may use food coloring paste (used for cake decorating) for more vivid colors.*

- Cook over medium heat, stirring constantly until a ball forms.  
- Knead until smooth.  
- Store in an airtight covered container.
EASY S’MORES

5 small marshmallows (They’re made from corn syrup!)
2 squares of graham crackers
10 chocolate chips

- Place the marshmallows on one graham cracker.
- Put the chocolate chips around the marshmallows.
- Microwave on high for 30 seconds.
- Place the other graham cracker on top.
- Enjoy!

FREEZER CORN

20-22 cups of raw sweet corn (approximately 2½ to 3 dozen ears)
1 pound butter
1 pint half and half

- Mix ingredients and place in a large roaster.
- Bake at 350 degrees for 1 hour, stirring two or three times.
- Eat!
- Or cool, then divide into freezer bags and freeze.