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Compilation relating to

USES AND PRODUCTS MADE OF CORN.

By

C. LOUISE PHILLIPS, Scientific Assistant, Grain Investigations
and
E. G. BOERNER, Grain Supervisor, In Charge, Grain Investigations.

Washington, D. C.
March, 1925.

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UNITED STATES DEPARTMENT OF AGRICULTURE
Bureau of Agricultural Economics
Grain Investigations

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C O N T E N T S.

PRODUCTS AND USES MADE OF CORN, INCLUDING SHELLED CORN, CORN STOCKS, LEAVES AND COBS

List compiled by C. Louise Phillips, Scientific Assistant, Grain Investigations, Bureau of Agricultural Economics, Department of Agriculture. Rev. 1925.

Absorbent for nitroglycerine in manufacture of dynamite.
Acetic acid
Adulterating para rubber
Alcohol
Appetizo
Axle grease
Beer
Binders for brushes
Boot and shoe heels
Bran
Breading meats and fish
Burned cobs for hogs
Buttons
Candy
Canned corn
Car springs
Car wheels
Cellulose
Chair cushions
Charcoal
Cigarette holders
Cloth
Cob flour
Cob sidewalks
Cob used for stock food
Coloring
Corn bread
Corn cob pipes
Corn cob washboards
Corn fritters
Corn and cornmeal ground together for stock
Corn hats
Corn hearts
Corn hulls
Cornmeal
Corn palaces
Corn pancakes
Corn screenings
Corn shorts
Cornstalks for stock food
Corn toasties
Cracker jack
Decorating purposes
Denatured alcohol
Dolls
Door mats
Dried corn
Dyspeptic's food
Electrical instrument parts formerly made of hard rubber
Element in dynamite
Face powder
Feeding of distillery refuse
Feed for livestock
Fiber
Filling horse collars
Filling for vehicle cushions
Flour
Fodder
Food for man
Fuel
Furfural
Germ meal
Germ meal cake
Gin
Glucose
Glue
Gluten feed
Grapenuts
Green corn for soiling
Green manure
Grits
Ground or cracked corn used for stock
Gum arabic
Gum labels
Gun cotton
Gun powder
Hay
Hominy (human food)
Hominy (stock feed)
Hulled corn
Husk floor rugs
Husks used for stock food
Imitation amber (Gutta percha)
Incense
Invalid food
Kormmoyd or corn rubbers
Korn krisp

PRODUCTS AND USES MADE OF CORN.

Cont.

Kornlet
Laundry soap
Library pastes
Linoleum
Lumber substitute
Malt
Mattresses
Molasses
Mucilage
Navy biscuits
Oil cloth
Oil meal
Oils -
 Machine
 Cylinder
 Salad
 Corn
 Glycerine
 Paragol
Oxalic acid
Paper -
 Oil paper
 Linen paper
 Stock paper
Paint
Papier maché
Parched substitute for coffee
Phonograph records
Photographic pastes
Pitch
Pipe stems
Pith for packing war vessels
Pop corn
Potash
Printers ink
Printing plates
Pulp board
Punk
Pyroxylin varnish
Radio equipment

Resin
Roasting ears
Roofing
Rubber substitute
Rubbers
Salves
Seed purposes
Shaving soap
Shelled corn used for stock food
Shoe horns
Shredded fodder for bedding
Silage
Sofa pillows
Stalks for fertilizer
Starch
 Maizena
 Crystal
 Confectionery
 Amidex
 Lump
 Laundry
 Powdered corn
Sugar
 Raw glucose
 Refined glucose
 Anhidrous sugar (glucose)
 Syrup for feeding bees
Syrup
Talcum powder
Tar
Telephone receivers
Toilet soaps
Toasted corn flakes
Varnish
Vinegar
Wax
Whiskey
Xylan
Xylose

VALUE AND USES OF THE CORN CROP.

U. S. Department of Agriculture, Yearbook Separate, 872. 1921. p.163-165.

Relative Value.

"The value of the corn crop to the American farmer is greater than the value of any other crop grown in this country. In 9 of the last 12 years the value of corn has been greater than the combined values of wheat and cotton. In 8 of these years the value of corn has been greater than the combined values of all cattle and swine produced for slaughter. The farm value of swine produced for slaughter has been second to the value of corn in every year since 1910.

"The average value of corn in the pre-war period, 1910 to 1914, was $1,577,000,000 annually. The higher prices from 1915 to 1919 raised the average annual value of this period to the stupendous sum of $3,024,000,000. The 1920 crop, the largest ever harvested, was valued at $2,150,000,000, prices having fallen from the war-time figures. The 1921 crop, which was only 4 per cent less than the record crop of the previous year, was valued at only $1,303,000,000 or 43 per cent of the annual value during the war period, and approximately one-sixth less than the pre-war value, although the crop was one-tenth larger than the pre-war average. The other crops and animal products increased in value during the war and decreased in 1920 and 1921, but not to the extent that the value of the corn crop decreased."

Uses.

"The hog is the largest direct consumer of corn. It is estimated that 40 per cent of the total crop is fed to swine on farms. Horses and cattle, it is estimated, account for 20 per cent and 15 per cent, respectively. The next largest use of corn is for human food, 10 per cent of the crop being consumed on farms and ground in merchant flour mills (principally for food). The percentage of the crop used directly for food appears small, but, considering our large production, corn is seen to be an important food. Other details regarding uses of corn are shown in the accompanying figure. The outstanding use of corn is as a feed for animals, more than 85 per cent of it being used in this way. The exports of corn as grain are almost negligible.

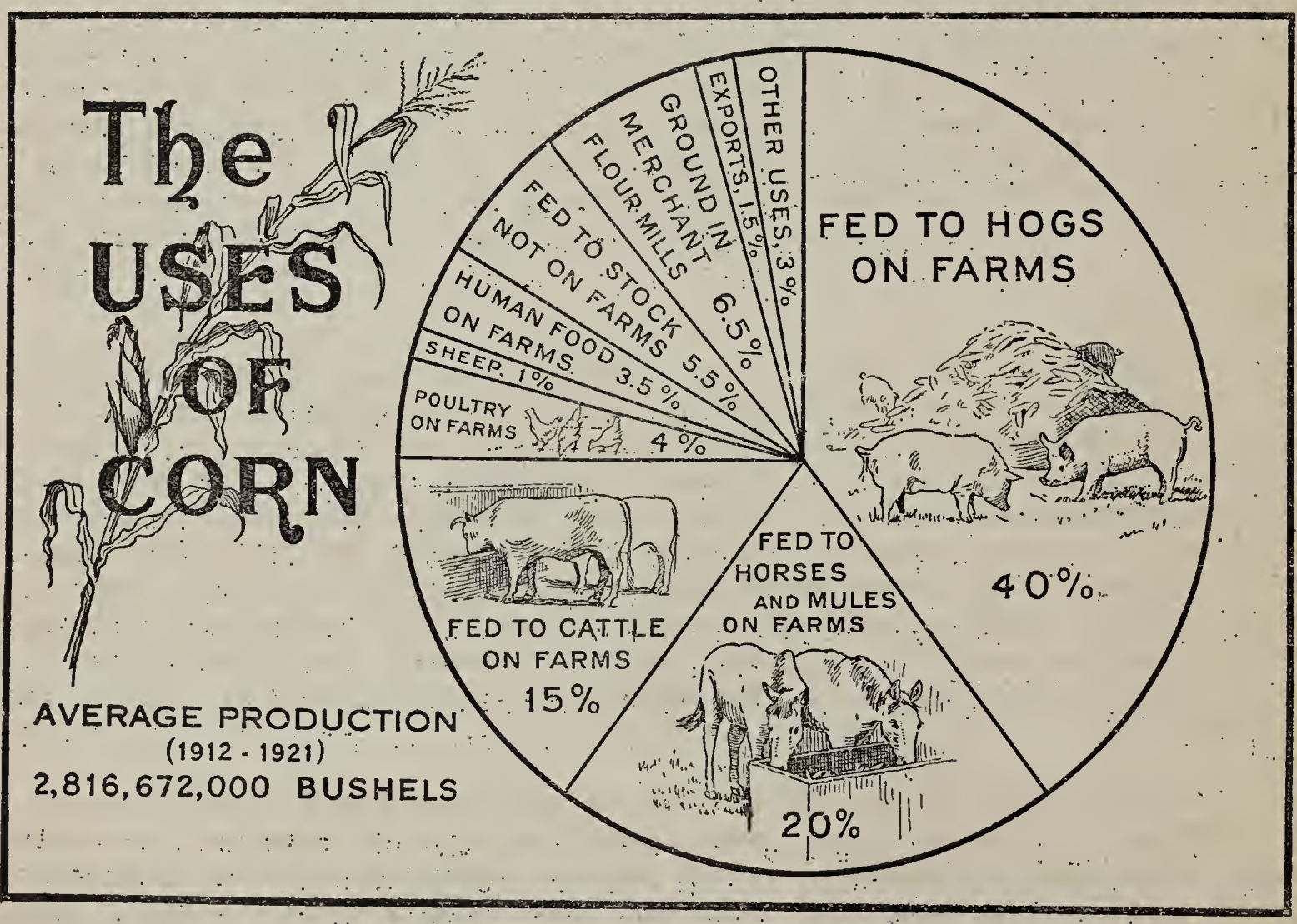
"In addition to the use of corn as grain the plant is used extensively in the form of silage, fodder, and stover, as feed for animals. In recent years, according to estimates by the Bureau of Markets and Crop Estimates, nearly 4 million acres of corn each year have been made into silage. More than 2-1/2 million acres of corn are cut for fodder, while large use is made of the stalks as feed for animals. More than 2 million acres have been grazed or hogged off each year for the last few years.

"The corn crop and the swine and cattle populations are intimately interrelated. With the exception of limited areas from which corn is largely

Uses. Cont.

sold as grain, because of the proximity of markets, swine are found most abundantly where corn production is greatest. In these areas, too, the finishing of cattle for market is a prominent industry. The six States, Iowa, Illinois, Nebraska, Missouri, Indiana, and Ohio, producing 48 per cent of the corn in 1921, had within their borders about 45 per cent of the swine of the country and over 25 per cent of the cattle other than milk cows on January 1, 1922. In addition these States produced 32 per cent of the chickens and 35 per cent of the hens' eggs produced in the United States in 1919.

"Corn, therefore, consumed either directly or in the form of meat and other animal products, is the principal source of food of the American people."



DISPOSITION OF AMERICAN CORN CROP.

U. S. Department of Agriculture, Bulletin 696. 1918. p. 9-10.

"Over four-fifths of the crop is consumed on farms; only one-fifth enters into general trade channels, part of which is shipped again to farms.

"About one-sixth of the crop is consumed in cities for industrial and other purposes.

"... Only about 82 per cent of the crop, on an average, is of merchantable quality. The quantity shipped out of the counties where grown, constituting in 1911-1915 only 19.4 per cent of the aggregate production of the United States, may be said to represent the corn moving into general trade channels; in round numbers, only one-half billion out of the two and three-quarter billion bushels. The balance remaining in the counties where grown, 80.6 per cent, consists principally of the corn consumed on farms where it is produced, and a small percentage of sales to local feeders and local markets. The major part of the crop never leaves the farms on which it is raised. The census for 1909 reported 23 per cent of the corn crop as having been sold. In that year, therefore, 77 per cent of the corn grown was retained on the farms where it was produced. This fraction includes the soft and unmerchantable corn. In the same year (1909) 18 per cent of the total harvest was shipped out of counties where grown; thus the difference between this 18 per cent and the 23 per cent sold off the farms represents local sales, or corn sold but not shipped out of counties where grown. This amounted in that year to but 5 per cent.

"The farm consumption approximates 83.4 per cent; it consists of the small fraction constituted by corn shipped from markets and farms to farms, and, chiefly, of the home-grown product. Horses and mules, as one item, and swine, each absorb more than one-fourth of the total production, three-fourths of a billion bushels each. These items are highly variable, as stated, depending upon size of crop, costs of other feeds and market prices of live stock.

"The urban consumption is more stable. ... Corn disposed of in cities, total only 16.6 per cent of the national production, or about a half billion bushels. To obtain aggregate urban receipts, there should be added some quantities re-shipped from markets to farms, which are included in this statement under farm consumption.

"The largest item in city consumption consists of the corn ground in merchant flour mills (180 million bushels or 6.5 per cent of the crop). In the Census for the year 1909, 80 per cent of the corn entering such mills was reported to be 'manufactured chiefly for human consumption,' and 20 per cent, or 42 million bushels, 'manufactured chiefly for live stock.' Additional quantities enter small custom mills, no recent data for which are available; this appears, however, to be included in the estimates of farm use. In the Census of 1909 it was reported to be 35 million bushels. Quantities fed to live stock in cities are of some importance, constituting about 5.4 per cent of production. Industrial uses absorb many million bushels, but amount to only a small percentage of the crop. Excepting its use in the manufacture of hominy, industrial demands furnish a market for poorer qualities of corn."

CORN PRODUCTION AND MARKETING MOVEMENT.

U. S. Federal Trade Commission. Report on the Grain Trade. Vol. 3, 1921. p.34-35.

Production and Distribution.

"The heaviest production of corn centers in Iowa and Illinois, although the crop area extends throughout all the agricultural regions east of the Rocky Mountains. As is well known, Chicago is the greatest distribution center for corn in America. For the 1920-21 crop the primary markets next in importance were St. Louis, Kansas City, Milwaukee, Omaha, Indianapolis, Minneapolis, and Peoria. The leading secondary markets in order of importance were Baltimore, New York, Buffalo, Philadelphia, and New Orleans. It should be noted that the local car-lot trade in corn is very extensive because of the numerous smaller markets.

Consumption of Corn.

"It is estimated that about 90 per cent of the corn crop is regularly consumed by hogs, cattle, horses, mules, and other animals, and 80 per cent of it on the farm where grown. In any case corn marketings comprise but a small proportion of the entire crop. Yet the crops are so large - varying roughly from 2,500,000,000 to 3,000,000,000 bushels - that the supplies available for the purposes of manufacture and conversion are always large, and the movement of corn is second in volume to that of wheat.

"The uses of the crop for human consumptive purposes may be summarized as follows:

> '*** When ground into meal it produces degerminated corn meal; when crushed it produces hominy grits; when subjected to certain chemical changes, it produces whisky, alcohol, and beer. When the starchy part is separated from the gluten and ground it produces starch. The remaining gluten is used for cattle feed and is called gluten feed. The starch may be subjected to certain chemical processes to produce glucose or corn sirup.'
> (Quoted from War Industries Board, Price Bulletin No. 10, p. 9-10.)

"Approximately 3 per cent of the corn crop (85,000,000 bushels) has been normally used in the manufacture of corn meal; about 1 per cent (28,000,000 bushels) in the production of grits; and about 2 per cent in the manufacture of cornstarch and glucose. These figures serve to indicate that the supply of American corn has been enormously in excess of the ordinary demands of manufacturers and converters.

Export Demand.

"The export demand for American corn has never been large. While exports averaged nearly 43,000,000 bushels for the six calendar years 1913-1918, they amounted to only 11,000,000 and 18,000,000 for 1919 and 1920, respectively. The largest export movement for a single year took place in 1916-17, when about 65,000,000 bushels were sent abroad to meet war-time demands. In view of the size of the crop, export demand is an inconsiderable factor in the corn markets."

CONSUMPTION OF CORN.

U. S. War Industries Board. Price Bulletin No. 10, 1919. p. 9-10.

"Composition of corn. - A grain of corn consists of three parts - the skin, the germ, and the endosperm. The skin consists of cellulose and contains about 6 per cent of the weight of the grain. The germ contains about 10 per cent of the weight of the grain. In the production of corn products, the skin and germ are generally removed and used in the manufacture of by-products. Skins are used as cattle feed, and are called corn bran. The germs contain oil and are used for the production of corn oil. The part of the germ remaining after the extraction of the oil is compressed into oil cake and is used for cattle feed. The endosperm constitutes about 84 per cent of the weight of a grain of corn and consists of protein and starch. When ground into meal it produces degerminated corn meal; when crushed it produces hominy grits, when subjected to certain chemical changes, it produces whisky, alcohol, and beer. When the starchy part is separated from the gluten and ground it produces starch. The remaining gluten is used for cattle feed and is called gluten feed. The starch may be subjected to certain chemical processes to produce glucose or corn syrup.

"The quantitative relation between a bushel of corn and its products is shown in the following table:

Conversion Table.

One bushel corn (56 pounds) makes 43 pounds of germinated corn meal.
One bushel corn (56 pounds) makes 35 pounds cornstarch.
One bushel corn (56 pounds) makes 40 pounds glucose.
One bushel corn (56 pounds) makes 4.62 gallons distilled spirits.
One bushel corn (56 pounds) makes 1 to 1-1/2 pounds corn oil.
One bushel corn (56 pounds) makes 10 pounds live hog.
One bushel corn (56 pounds) makes 12 pounds gluten feed.
One bushel corn (56 pounds) makes 2 pounds oil cake.

"Consumption - General statement.- The use made of a normal corn crop of 2,800,000,000 bushels is approximately as follows:

	Number of bushels	Per cent of total crop
Hogs	800,000,000	28.4
Horses and mules	800,000,000	28.4
Other animals	800,000,000	28.4
Corn meal	85,000,000	3.0
Distilled spirits	25,000,000	0.9
Beer	16,000,000	0.7
Starch	24,000,000	0.8
Glucose	27,000,000	1.0
Hominy grits	28,000,000	1.0
Seed	18,000,000	0.6
Exports	50,000,000	1.8
Waste	140,000,000	5.0
Total	2,813,000,000	100.0

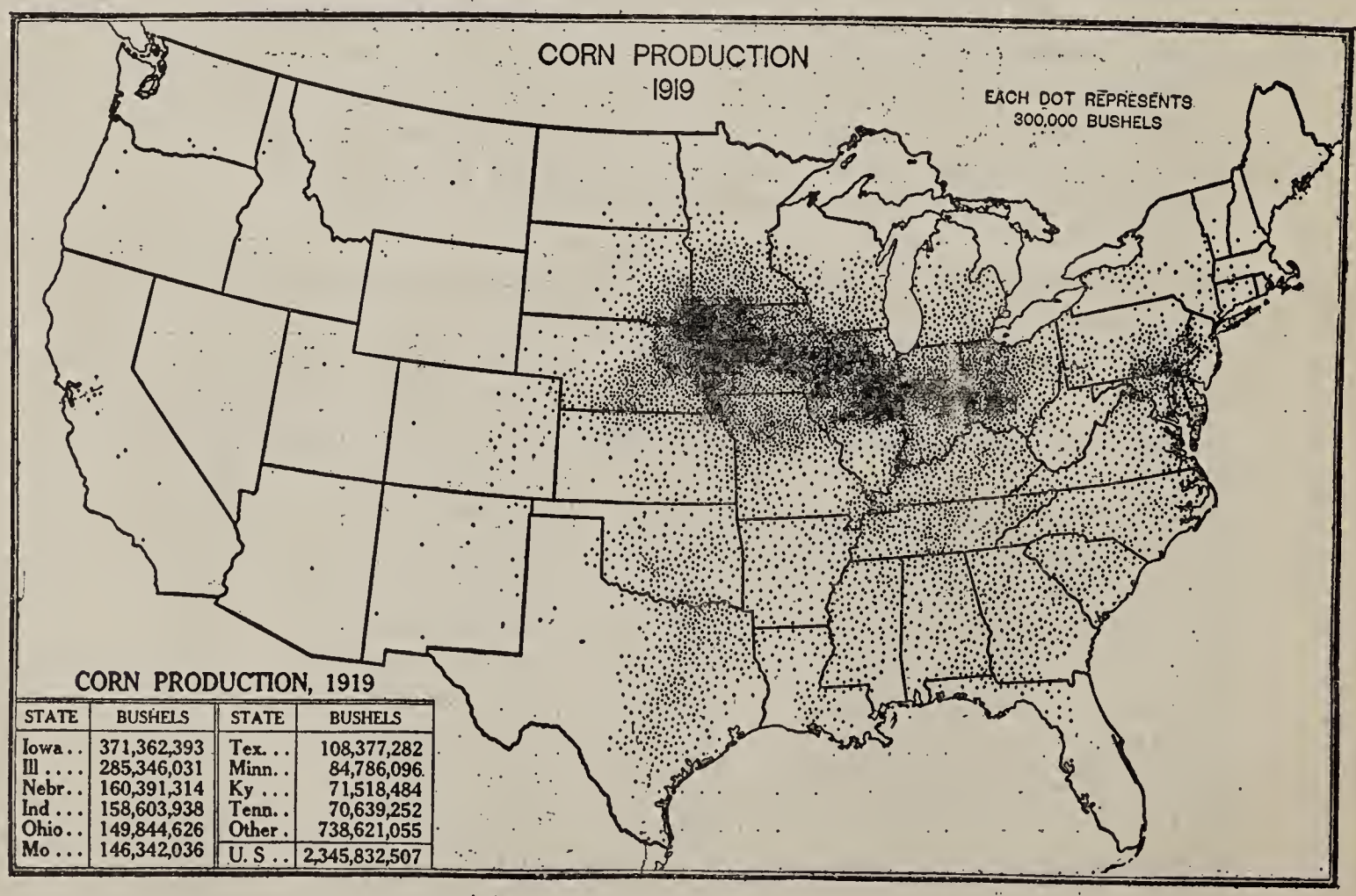
"The proportion of the crop used for different purposes necessarily varies somewhat from year to year according to the size of the crop, which is subject to great fluctuations. The proportion, however, which is utilized for industrial purposes is fairly constant. When the crop is large, a relatively greater amount is fed to meat-producing animals. The amount fed to hogs increases faster than the amount fed to horses, because the number of horses from year to year remains more nearly constant."

Map Showing Production of Corn in United States, 1919.

U. S. Department of Agriculture Yearbook, 1921. p. 437.

"Corn is the great American cereal, constituting about 60 per cent of the tonnage of all cereals grown in the United States, and over 50 per cent of the value. More than half of this crop is produced in the Corn Belt; but corn is the leading crop in value also in the Corn and Winter Wheat Belt, and is the all-important cereal in the cotton Belt. ...

"In the Corn Belt most of the corn is fed to hogs, cattle, and horses on the same farm that it is grown ...but a considerable quantity, amounting to 41 per cent of the crop in Illinois in 1919, and about 30 per cent in Iowa, South Dakota, and Nebraska, is sold to nearby farmers, is shipped to consumers in the South and East, is exported largely through Chicago and the Atlantic ports, or is made into starch and glucose."



CORN PRODUCTION, 1919

STATE	BUSHELS	STATE	BUSHELS
Iowa..	371,362,393	Tex...	108,377,282
Ill	285,346,031	Minn..	84,786,096
Nebr..	160,391,314	Ky ...	71,518,484
Ind ...	158,603,938	Tenn..	70,639,252
Ohio..	149,844,626	Other.	738,621,055
Mo ...	146,342,036	U. S ..	2,345,832,507

PRODUCTS FROM THE CORN KERNEL.

- Corn Kernel
  - germ
    - corn oil
      - table oil
      - dyers oil
      - soap
      - glycerine
      - rubber substitute
    - oil cake
    - oil meal .... cattle food
  - body or endosperm
    - starch
      - table starch
      - laundry starch
    - hydrolyzed
      - dextrose
      - glucose
      - maltose
      - corn syrup
      - hydrol
      - tanners' sugar
      - cerelose
      - white dextrin
      - canary dextrin
      - British gum
      - envelope dextrin
      - foundry dextrin
      - anidex
    - gluten
      - vegetable glue
      - vegetable casein
      - gluten meal
  - hull ..... bran

PROCESS OF THE MANUFACTURE OF CORN PRODUCTS.

American Manufacturers' Association of Products from Corn.
Pamphlet entitled "All Made From King Corn." n. d.

The first step in the process of manufacturing corn products is to steep the corn. "The steepwater, containing the solubles of the corn, is drawn off and subsequently evaporated and incorporated with the gluten feed.

"The steeped corn is then ground coarsely so that the germ is not broken, and the resulting mass is submitted to a process whereby, by taking advantage of the difference in the specific gravity of the component parts, a separation into germs, hulls, and endosperm is effected.

"The germs are dried and from them is produced Oil and Oil Cake.

"The hulls are likewise separated and mixed with the gluten and corn solubles to form Gluten Feed.

"The endosperm, which is mixed with water, is separated into its component parts (starch and gluten) by processes dependent on the different specific gravities.

"The gluten is mixed with the hulls and the corn solubles, which, after drying and grinding, constitute Gluten Feed.

"From the starch are produced the three following classes of products:

"1. The Dry Starches of various qualities.
"2. Corn Syrups and Sugars. These products are obtained by the hydrolization of starch and by subsequent refining and evaporation.
"3. The Dextrines. These are produced from starch by a process of roasting."

Products Manufactured From Corn Gluten Feed.

"Process of Manufacture- As heretofore described, Gluten Feed is a concentrate of the corn, and consists of a mixture of the hull or bran, the gluten and the corn solubles, which are mechanically separated from the starch and the germ of the grain.

"Use of Gluten Feed- The feed contains in concentrated form the protein of the corn, and is a very valuable feed for dairy cows, stock, chickens, etc."

Corn Oil Made Into:

"Corn Oil, Refined Corn Oil, Soluble Corn Oil, Cotton Softener, Glycerine, Corn Oil, Fatty Acids, Paragol.

"Process of Manufacture of Corn Oil- The germs, which contain the oil, after separation from the remaining portion of the corn, are dried, ground and subjected to hydraulic pressure whereby the oil is extracted."

Uses of Crude Corn Oil

"For the manufacture of soap.
"For Paragol or rubber substitute.
"Paints, varnishes."

Edible Corn Oil

"Corn Oil is further refined by a treatment which removes the free fatty acids, etc., improves the taste, and lightens the color.

Uses of Edible Corn Oil

"For edible purposes, shortening for bread and cake.
"For frying and cooking and salad oil.
"It also finds uses in medicinal preparations."

Oil Cake

"The part of the germ from which the oil has been extracted is in the shape of a cake and is called Corn Oil Cake. It is mostly exported in this form. Some is ground and sold as Corn Oil Cake Meal."

Uses of Corn Oil Cake

"In the cake or ground form, for cattle feed.
"Mixed with phosphates, as 'Hog Meal.'"

Soluble Corn Oil

"This is a sulphonated oil, similar to Turkey Red Oil. It is soluble in water and used in the textile industry in the preparation of sizes, in which it replaces tallow or fats as a softening agent. It also tends to brighten the color of the goods."

Rubber Substitute

"This is manufactured from Corn Oil by a vulcanizing process.

Starches

"Process of Manufacture of Starches- The starch, separated by settling from the gluten, is removed, then dried.

"The physical forms of various classes of starches are obtained by different methods of drying, by which it is possible to produce the pearl, crystal, or lump form."

Uses of the Various Starches

"For Foods - Jellies and puddings, for bakers.
"For baking-powder, pie filling, pastes and sauces.
"For Candies - Gum-drops and some other confections, and as a molding material for use in casting cream centers, marshmallows, bonbons, etc.
"For laundry purposes.
"For sizes for stiffening and finishing yarns and fabrics in textile industries.
"In paper manufacture as a filler, finisher and size.
"For cosmetics and adhesives, etc.
"In the manufacture of high explosives."

Dextrine: "White Dextrine, Canary Dextrine, British Gum."
"Process of the Manufacture of Dextrine - Dextrines are made by roasting the starch, the various varieties depending upon the time and heat applied."

Uses of Dextrine

"In the textile industry dextrines are used in sizes for strengthening the fibre and finishing the fabric.
"For cloth, carpets, twine, etc.
"For thickening colors, for calico, and other printing.
"For gums and glues, ink, mucilage and adhesives.
"In the fireworks called 'sparklers,' coffee and rice polishing.
"In food sauces and many other ways."

Corn Syrup: "(Mixing) Corn Syrup, (White) Corn Syrup.

"Process of the Manufacture of Corn Syrup - Starch is mixed with water and heated under pressure with a minute quantity of hydrochloric acid. The starch is thereby hydrolized into a liquid, the solids of which are composed of about half dextrine and half of the sugar, glucose. The acid is neutralized by carbonate of soda and forms harmless sodium chloride (table salt). It is then filtered to remove small amounts of the fat and protein occurring in the starch and decolorized by passing through boneblack, similarly as cane sugar is filtered in all cane sugar refineries. It is then evaporated to various degrees of concentration.

Uses of Corn Syrups

"For mixing with cane syrup and molasses in the preparation of mixed syrups.
"For confectionery, baking, syrups, jams, jellies, preserves, mincemeat and other desserts.
"In the manufacture of ice cream.

PROCESS OF THE MANUFACTURE OF CORN PRODUCTS.

Cont.

Uses of Corn Syrups Cont.

"Food sauces.
"In the manufacture of shoe polishes.
"For finishing cores in iron foundries.
"In silvering glass for mirrors.

Sugars

70 sugar.
White 80 sugar.
Cereal sugar.

"Process of the Manufacture of Corn Sugar- The process of manufacturing corn syrup is continued until crystallization results."

Uses of Corn Sugar.

"For infant feeding.
"For diabetics.
"For sugar tolerance test.
"For surgical shock (intravenously).
"In the manufacture of: ice cream, caramel or sugar coloring, vinegar.
"In bread making.
"In the manufacture of lactic acid for tanning, for filling leather, etc."

AMOUNT OF CORN USED FOR MILL PRODUCTS.

The Census of Manufacturers, Flour Mill and Grain-Mill products, 1923, report that 122,168,474 bushels of corn were ground in 1921, in 1923, 125,773,592 bushels were ground, which was an increase of 3 per cent.

For corn meal there is shown an increase of 12 per cent in quantity, from 10,932,155 barrels in 1921 to 12,244,729 barrels in 1923, together with an increase of 31.8 per cent in value, from $39,704,222 to $52,327,117, the average value per barrel at the mill having risen from $3.63 to $4.27.

AMOUNT AND VALUE OF CORN PRODUCTS - STARCH, SIRUP AND OIL - MANUFACTURED IN THE UNITED STATES, 1921 AND 1923.

Census of Manufacturers: Corn Sirup (Glucose) and Starch, 1923.

Products, by Class, Quantity, and Value for the United States.

	1923	1921	Per cent of increase or decrease (-)
Total value	$116,560,034	$80,040,795	45.6
Corn sirup:			
Pounds	1,164,467,149	(a)	---
Value	$33,790,888	$26,068,369	29.6
Grape sugar:			
Pounds	527,909,513	152,909,513	247.2
Value	$16,797,033	$4,542,238	269.8
Starch:			
Pounds	858,395,196	894,054,407	-4.0
Value	$29,750,747	$25,522,237	16.6
Corn---			
Pounds	839,382,402	860,224,469	-2.4
Value	$28,727,841	$24,305,565	18.2
Potato---			
Pounds	4,689,751	8,924,927	-47.5
Value	$182,168	$323,192	-43.6
Other starches---			
Pounds	14,323,043	24,905,011	-42.5
Value	$840,738	$893,480	-5.9
Corn oil:			
Pounds	106,947,373	(b)	---
Value	$13,873,157	$11,102,106	25.0
Corn oil-cake and meal:			
Tons	62,384	16,483	278.5
Value	$2,460,415	$614,054	300.7
Stock feed: c			
Tons	455,462	396,340	14.9
Value	$17,610,435	$10,481,284	68.0
All other products, value...	$2,277,359	$1,710,507	33.1

a No comparable data.

b Reported as 11,681,366 gallons.

c The figures in this table refer only to the products of establishments engaged primarily in the manufacture of corn sirup and starch. They cover, therefore, only a minor proportion of the total stock feed produced by all classes of establishments. This total has not yet been ascertained, but will be shown in the final report of the present census.

PRODUCTS DERIVED FROM CORN COBS.

The Journal of the American Society of Mechanical Engineers, Vol. 40, No. 6. June, 1918. p. 496-497.

"In a paper read before the New York section of the American Chemical Association at its regular meeting last Friday night, Dr. F. B. LaForge of the Bureau of Chemistry said that with the American corn crop estimated at 3,000,000,000 bul, which means probably about the same amount of corn cobs now going to waste, the United States Bureau of Chemistry has discovered practical and probably commercial methods whereby 37-1/2 per cent of their substance can be converted into glucose, 30 per cent into usable mucilage, and 5 per cent into zylose, in addition to much new baking-powder material and a large quantity of acetic acid, with probably other valuable by-products yet to be discovered.

"According to Dr. LaForge, there are four principal materials which may be prepared successfully from corn cobs; about 30 per cent of a gum resembling dextrine but composed largely of polymerized xylose, instead of glucose, as in the case of dextrine. This material should be useful as an adhesive in the paper-box industry, for bill posting, wall papering, labeling, etc. It would be extremely cheap, and as far as its sticking qualities are concerned, it is probably about the equal of the dextrine preparations now commonly used. Its use would make possible an enormous saving of the foodstuffs now used in making dextrine and other starch preparations.

"From 5 to 6 per cent of the pentose sugar xylose is another product. This sugar has been up to now a comparatively rare substance, but one and possibly two uses for it have been tried out or are being worked out and will be described later.

"Acetic acid is obtained in the preparation of xylose in amounts which, at its present price, would be a very great source of profit in working up large amounts of cobs and at all times would be an important by-product.

(Journal of Commerce, May 13, 1918, pp. 15 and 17)"

USE FOR CORN OIL

Winfield, Harriet. The Oil of Maize. Easton Pa., Chemical Pub. Co. 1899. p. 7.

"... The most important commercial application of maize oil is its use in the manufacture of soap. It is peculiarly fitted for this purpose, saponifying with great ease in the presence of either hot or cold alkali and forming a light-colored soap of excellent quality. Large quantities of the oil are exported yearly for the use of the English and Belgian soap-makers, but little attention is paid to it for this purpose in America."

FINDING USES FOR THE CORN COB.

American Elevator and Grain Trade. November, 1924. p. 366-367.

"The question of what use can be made of 15 to 20 million tons of corn cobs wasted annually in the corn belt was the topic of an item published recently in the Research Narratives issued by the Engineering Foundation of New York. This article says, among other things:

"Chemists of the Department of Agriculture, working on the subject since 1918, have discovered new values in cobs and processes for making them commercially available. Iowa State College is investigating production from cobs of furfural, oxalic and acetic acids, wood alcohol, charcoal, activated char, pitch, tar, oils, cob flour, incense, punk, a plastic material, and fermentation products.

"The pithy, wood shell, and scaly exterior, or chaff, of the cob, physically so different, chemically are alike. Cobs season in 11 days; wood requires one to two years. Great saving results in interest on raw material carried in stock for cob products.

"When cobs are cooked for a few minutes under pressure in superheated water, adhesive materials are extracted. These compounds belong to the same group of chemicals as starch, dextrine and sugars. Pentosan adhesives can be used for pasting fiber boxes and cheap paper bags, and for other purposes not demanding high-grade, strong adhesives. A special use proposed is in manufacture of briquettes from fine sizes of anthracite, of which a superabundance results in preparing that coal for market. Thus utilization of waste cobs could enhance materially the value of near-waste coal; much experimental work has been done.

"When cobs are digested for about two hours with steam under 135 pounds pressure per square inch, with very little sulfuric acid, a different product results - furfural. Furfural is an aromatic liquid about one-sixth heavier than water, boiling at 161 degrees C., soluble in 11 parts of water, nearly colorless when first prepared, but darkening on exposure to air and light. It can be obtained also from oat hulls, bran and other vegetable substances. Its use had been limited because of the high cost by methods heretofore employed. In 1920, possibly 50 pounds were used in the United States, only as a laboratory reagent; the price was about $30. In France and Germany furfural has been made as a by-product in the manufacture of alcohol from wood waste. Annual production is now thousands of pounds, and since 1922 the price has been reduced to 25 cents.

"Attention has turned to discovery of additional uses for furfural and enlargement of its market. More than 60 patents on its production and utilization have been issued, mostly within the past five years, in the United States and other countries.

FINDING USES FOR THE CORN COB.

Cont.

"During the war, a shortage of acetone could easily have been met by distilling cobs.

"If cobs be treated with phenol or cresol in presence of an acid, a sticky mass results on heating, which ages to a hard, black substance which can be pressed into shape.

"There is a promising field in the manufacture of resins similar to Bakelite, suitable for parts of electrical instruments, for printing plates, and various other molded articles. These phenol furfural resins are infusible and insoluble; they have high insulating qualities, great strength and great resistance to water and chemicals. They have a large field in radio equipment. Phonograph records may be made from them. There are also innumerable uses for fiber impregnated with these resins where great toughness and resistance are of value."

USES FOR CORN COBS.

American Elevator and Grain Trade. February 15, 1923. p. 548.

..."Laboratory work has developed cheap processes for extracting from the corn cob a synthetic resin from which can be made telephone receivers, phonograph records, noiseless gears, etc., furfural which has many uses in industry, including a base for varnish, mucilage, etc.; xylan, a valuable base for sulphur dyes; cellulose from which artificial silk is made, and which is also used in waterproofing, paper sizing, cement, etc.; and finally as an absorbent of nitroglycerine in the manufacture of dynamite.

"In commercial practice all of these materials are now obtained from substances less plentiful and less efficient than corn cobs. There is only one thing that stands in the way of the general use of corn cobs in various industries, and that is that it has another use locally as fuel. Corn cobs have fuel value of 6,700 b.t.u. per pound compared with ordinary anthracite coal of 11,800 b.t.u. The value of corn cobs per ton is therefore about half that of coal. Moreover it requires no time or trouble in transportation, for it is on the farm or elevator where it can be used. If it develops that industry is able to pay over half coal prices per ton at country stations the quantity available would be unlimited; until that time comes corn cob products will largely be developed in the laboratory more than in the factory."

LOWLY CORNCOB SOURCE OF MOTOR FUEL SUBSTITUTE.

NEWLY-FOUND FURFURAL ALSO TAKES PLACE OF HARD RUBBER.

U. S. Discovery - Bureau of Chemistry Reveals Substance Can Be Used For Formaldehyde. - The Washington Herald. June 12, 1922.

"The Department of Agriculture, after six years of trying, has rescued the lowly corn cob from the ignominy of hog-fodder and raised it to the level of a substitute for hard rubber and a possible motor fuel supply.

"This has been made possible through the extraction of a corn cob by-product known as furfural, according to Dr. W. W. Skinner, assistant chief of the Bureau of Chemistry. The production of furfural on a commercial scale at about 6 cents a pound was made possible through the work of Dr. Frederick B. La Forge and Gerald Mains, of the Bureau of Chemistry.

Used for Many Articles.

"'The importance of furfural production on a large scale is apparent,' Dr. Skinner said, 'when it is realized that such widely used articles as printing plates - light, durable substitutes for electrotypes - phonograph records, varnishes, pipe stems, cigarette holders, electrical instrument parts formerly made of hard rubber, buttons, binders for brushes, glue, and a hundred other kindred articles are now being manufactured from synthetic resin compounds. These compounds are made with furfural.'

"The synthetic resins industry, since chemists discovered the secret of making them about fifteen years ago, has had a remarkable growth. The raw materials used in this industry are chiefly formaldehyde and phenol (carbolic acid). These two compounds, chemically combined, condense into a solid which is highly valuable as the basis for making the articles enumerated. Thorough tests have proved furfural to be an excellent substitute for formaldehyde in this work.

Can Be Used as Fuel.

"The possibilities of conservation may be seen when it is explained that the source of formaldehyde is methanol (wood alcohol), and that methanol is produced chiefly from the destructive distillation of hard woods, such as birch, beech, oak, maple and elm. The soft woods, while they are more plentiful in America, produce such low yields of methanol that they are of small value as a source of supply.

"The present price of formaldehyde is 8 to 10 cents per pound for a 40 per cent solution. Under methods of producing furfural now in general use, the product sells for about 50 cents per pound. The present price of methanol is about 60 cents per gallon.

"Dr. La Forge has reported the successful use of furfural as a fuel in an automobile engine. But, because of its high boiling point, he said, it cannot be used with the type of carburetor suited to gasoline.

LOWLY CORNCOB SOURCE OF MOTOR FUEL SUBSTITUTE.

NEWLY-FOUND FURFURAL ALSO TAKES PLACE OF HARD RUBBER.

Cont.

Will Erect Plant.

"The method of producing furfural is simple: The corn cobs, with some water, are placed in a cylinder or pressure cooker and steam at about 135 pounds pressure is turned in. After cooking about two hours, the furfural comes out of the corn cobs and is blown off with steam passed through a condenser and collected as a solution of furfural in water. This solution is then distilled in a special apparatus for the separation of the furfural from the water.

"Plans are now under way, it was announced, for the erection of the first commercial plant to utilize this new process. It will probably be located somewhere in the corn belt, where raw materials are close at hand."

BUILDING MATERIAL FROM CORN COBS.

Paul Gruber and H. C. Bashroim, Pittsburgh, Pa., (U. S. Pat. No. 1,427,378) propose the use of corn cobs in the manufacture of a lumber substitute where high tensile strength is not required.

The weight of the material approximates that of light wood and may be shaped by wood-working tools the same as lumber. It is very desirable for making spools, and it is estimated that they can be produced more cheaply than similar spools from birch wood. This material is also adapted for a large number of other uses, such as picture frames and mouldings, or it may be shaped with rolls to form a wall board of the desired thickness and width.

Prof. Elton R. Darling of Milliken University at Decatur, Illinois, claims that the substitute for lumber which may be made from corn cobs will withstand wear and tear as well as any hardwood and will withstand a pressure of 10,000 pounds to the square inch.

In making this wood substitute the cob may also be made to yield other by-products such as mucilage, sugars, and furfural.

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Compiled by C. Louise Phillips, Scientific Assistant, Grain Investigations, Bureau of Agricultural Economics, U. S. Department of Agriculture. 1925.

U.S. Department of Agriculture Publications.

Comparison of corn oils obtained by expeller and benzol extraction methods, by A. F. Sievers. 1922. 20 p. (Dept.Bul.1054)

Composition of corn (maize) meal manufactured by different processes and the influence of composition on the keeping qualities, by A. L. Winton, W. C. Burnet, and J. H. Bornmann. 1915. 31 p. (Dept.Bul.215)

Corn and its uses as food. 1923. 27 p. (Farmers' Bul.1236)

Corn cobs found to yield furfural. (In Weekly News Letter, v.7, no.42, May 19, 1920, p. 6)

Corn meal as a food and ways of using it, by C. F. Langworthy and C. L. Hunt. Rev. 1919. 28 p. (Farmers' Bul.565)

How to select foods. II. Cereal foods, by C.L. Hunt and H.W. Atwater. 1917. 23 p. (Farmers' Bul.817)

Preparation of an edible oil from crude corn oil, by A. F. Sievers and J. H. Shrader. 1922. 25 p. (Dept. Bul. 1010)

Production and conservation of fats and oils in the United States, by H. S. Bailey and B. E. Reuter. 1919. 48 p. (Dept. Bul. 769)

Production and utilization of corn oil in the United States, by A. F. Sievers. 1920. 23 p. (Dept. Bul. 904)

Products and uses made of corn. List compiled by C. L. Phillips. Rev. 1925.

Use for waste corn cobs. (In Weekly News Letter, v.6, no.36, April 9, 1919, p.14)

Usesmade of the corn crop. (In Monthly Crop Report, v.3, no.6, June, 1917, p.50)

[Uses of corn] (In The Corn Crop, by C. E. Leighty and others, in Yearbook, 1921, p.164-165)

Miscellaneous Publications.

All made from King Corn. Chicago, American manufacturers' association of products from corn [n.d.] 15 p.

A bibliography of investigations bearing on the composition and nutritive value of corn and corn products, by M. H. Keith. Washington, National research council, 1920. 178 numb. leaves. mimeographed.

Commercial utilization of corn cobs and oat hulls. Ames, Iowa. (Iowa Agr. Exp. Sta. Bul.) [In press, Jan. 1925]

Corn and corn products used as food, by Lucile Wheeler. Urbana, 1917. 19 p. (Ill. Univ. Col. Agr. Ext. Circ. 9.)
Issued in cooperation with the U.S. Department of Agriculture.

Corn and its uses. Chicago, American manufacturers' association of products from corn [n.d.] 12 p.

A corn cob enthusiast. (In American Elevator and Grain Trade, v.41, no.8, Feb. 1923, p. 548)

Corn cobs converted into lumber. (In Grain Dealers' Journal, v.51, no. 8, Oct. 25, 1923, p. 553)

Corn production and the marketing movement: production and distribution, consumption of corn, export demand. (In U.S. Federal trade commission. Report on the grain trade. v.3: Terminal grain marketing, 1921, p.34-35)

Corn syrup. How it is made and for what it is used. Clinton, Iowa, Clinton sugar refining co. [19-]

[Diagram showing the] industrial uses of the corn plant. (In Crissey, Forrest. The story of foods. Chicago, Rand McNally & co. [1917] p. 63)

Finding uses for the corn cob. (In American Elevator and Grain Trade, v.43, no.5, Nov. 1924, p.366-367)

Furfural from corncobs, by F.B. LaForge and G.H. Mains. (In Industrial & Engineering Chemistry, v.15, no.5, May,1923, p.499-502; v.15, no.8, August, 1923, p.823-829; v.15, no.10, Oct. 1923, p.1057-1060; v.16, no.4, April, 1924, p.356-359)

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Many uses of corn. (In Va. Dept. Agr. and Immigration. Yearbook, 1920. (Bul.48) p.41-42)

The oil of maize (Zea Mays)... by Harriet Winfield. Easton, Pa., The Chemical publishing co., 1899. 49 p.
Thesis (Ph.D.) Columbia University.
Bibliography: p.44-49.

Process of the manufacture of corn products. Chicago, American manufacturers' association of products from corn [n.d.] 16 p.

Products derived from corn cobs. (In American Society of Mechanical Engineers. Journal [now Mechanical Engineering] v.40, no.6, June 1918; p.496-497)

Simultaneous production of pentosan adhesives and furfural from corncobs and oat hulls, by F.B. LaForge. (In Industrial & Engineering Chemistry, v.16, no.2, Feb. 1924, p.130-131)

UNITED STATES DEPARTMENT OF AGRICULTURE
Bureau of Agricultural Economics
Grain Investigations.

Compilation
relating to

USES AND PRODUCTS MADE OF CORN

Supplement to

USGSA-GI-31

BY

C. Louise Phillips, Scientific Assistant, Grain Investigations
and
E. G. Boerner, Grain Supervisor, In Charge, Grain Investigations.

Washington, D. C.
April, 1926.

UTILIZATION OF THE CORN CROP.

U. S. Dept. of Agr. Crops and Markets, Vol. 3, Sup. 1. Jan. 1926. p. 8.

"A study of the utilization of the corn crops of 1923, 1924, and 1925, has been made by the United States Department of Agriculture to determine how much of the crop is actually husked for grain, cut for silage, and hogged down and cut for forage. Estimates of acreage, yield per acre, and production have been made for many years for the corn crop as a whole, regardless of its utilization, the estimated yield per acre being applied to the total acreage.

"In 1925, of a total corn acreage of 101,631,000 acres, 86,339,000 acres were utilized for grain; 3,916,000 acres for silage, and 11,376,000 acres were cut for forage or hogged down. The acreage of corn for grain in 1925 was 1,600,000 acres greater than in 1924, but 400,000 acres less than in 1923. The acreage of corn for silage in 1925 was 400,000 acres less than in 1924, and almost the same as the acreage in 1923.

"The amount of corn estimated to have been husked or snapped in 1925 is 2,416,000,000 bushels, which is 500,000,000 bushels greater than in 1924, but nearly 100,000,000 bushels less than in 1923. Production of silage was 31,000,000 tons in 1925, which is about a 10 per cent increase above the production in both 1924 and 1923.

"In 1924 considerable areas of corn went into silos because it was unfit for husking, being immature or frosted. The amount cut for forage was also increased materially because of the immaturity of the crop at the time of the first killing frost in the fall. The crops of both 1923 and 1925, on the other hand, were generally well matured.

"Corn for silage in 1923 yielded 7.3 tons per acre, in 1924 6.6 tons, and in 1925 8.0 tons.

"Corn for grain in 1923 yielded 28.9 bushels per acre, in 1924 the yield was 22.7 bushels and in 1925 it was 28.0 bushels per acre.

"The quality of the 1925 crop of corn is somewhat above average, but the moisture content at time of harvest was reported rather high in a number of States because of the wet weather and lack of sunshine. Drying out of corn was further retarded by weather conditions during November, but in December dry cold weather was helpful."

AMOUNT OF CORN PRODUCTS MANUFACTURED.

American Elevator and Grain Trade. January, 1926. p. 438. Editorial.

"...In 1924, a total of 557,160,516 pounds of corn sugar was manufactured. The association estimates that in 1926 the output could easily be raised to a billion pounds if the new demand is sustained.

"The refining companies manufactured also in 1924 a total of 1,195,770,198 pounds of corn syrup; 876,472,000 pounds of corn starch; 80,000,000 pounds of corn oil, and 500,000 tons of corn gluten feed. A total of 75,349,000 bushels of corn was ground in that year to make these products. In the year just closed the grind is estimated at 71,000,000 bushels.

FIFTY MILLION BUSHELS OF CORN USED TO MAKE CORNSTARCH.

U. S. Dept. of Agr. Official Record, Vol. 2, No. 47, Nov. 21, 1923, p. 3.

"The manufacture of cornstarch has grown to such proportions in the United States that the industry now consumes about 50,000,000 bushels of America's great crop each year. From each bushel of corn the average manufacturer makes 33 pounds of cornstarch, and in 1921 the 10 largest concerns made nearly 1,650,000,000 pounds of this product, which was more than 90 per cent of the total produced that year. This industry, which began in the United States in 1844, has been increasing greatly in recent years. By 1880 the factories had reached a productive capacity of 230,000,000 pounds and practically all of it was consumed here. By 1921 there were nearly 50 plants and $6,000,000 worth of the output was exported. These figures are from a report recently made by the Department of Agriculture as a result of an investigation.

"The department, through the Bureau of Chemistry, which enforces the food and drugs act, finds that cornstarch, with the possible exception of granulated sugar, is the least adulterated of all food products appearing on the markets. In addition to being used for food, it is also used for many technical purposes.

"In the food industry cornstarch finds its greatest use as the basis for the manufacture of corn sirup or glucose about one-half of that produced in 1921 having been used for that purpose. It is employed by confectioners in making gumdrops, by housewives and chefs in thickening sauces and making custards. Confectioners also use it for forms into which soft candy is poured in making bonbons. Large quantities are used in the manufacture of baking powder and pie fillers. It is also an important ingredient in cosmetics and pastes and is used to a limited extent in pharmaceutical preparations."

HISTORY OF THE MANUFACTURE OF CORN PRODUCTS.

Abstracted from article by I. B. Wagner. The Corn Products Industry. (In Trans. of the Amer. Institute of Chemical Engineers, Vol. 6, 1913. p.1-11.)

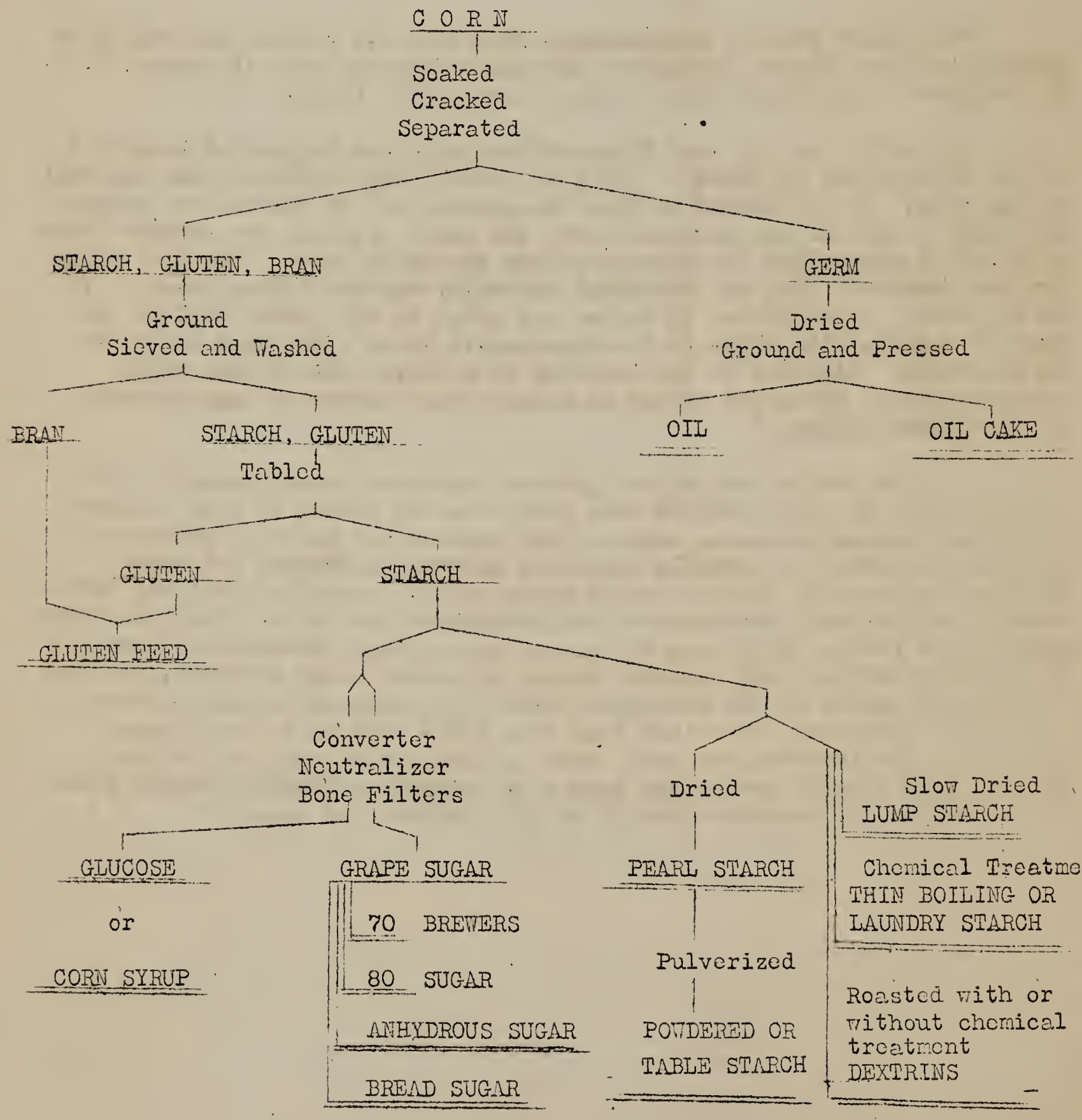
"The first product manufactured from corn was starch, and the first manufacturer was Thomas Kingsford, his plant being located at Oswego, N. Y. He commenced operations about seventy years ago." (1843)

The author states that "gluten" was the first by-product recovered in the manufacture of starch. Later the "bran" was recovered from the hull of the corn. In the course of time the manufacture of glucose was started and still later oil was recovered from the germ. Finally the chemist found a method of separating the glycerine from the fatty acids. The last waste product converted into an industrial commodity was the "steep water." It is collected, concentrated in vacuo, and added to the gluten feed in the form of a syrup with which it is subsequently dried - the feed acting as an absorbent. "Applied to the industry as a whole, this former waste ("steep-water") furnishes to-day an annual gross income of approximately 1 1/2 million dollars."

"...The development of our products occurred simultaneously, and to the series of bulk products were added, in the course of time, a large number of special products, such as thin boiling and modified starches, suitable for every conceivable technical purpose, dextrines and gums, special varieties of glucose, mixed table syrups, so-called '70' and '80' sugars, and refined, hydrogenated and vulcanized corn oils. There is every prospect of further additions to the present number. Products of corn, in one form or another, are consumed to-day in almost every industry, and they reach every corner of the civilized world. Figuratively speaking, this branch of efficiency was raised from 1 to 100 - that is to say, where originally the industry was based upon manufacture of only one product, to wit, corn starch, to-day the number of separate articles obtained from corn presents the formidable array of 100 products and more."

DIAGRAM SHOWING STEPS IN THE MANUFACTURE OF VARIOUS PRODUCTS FROM CORN.

Dr. A. P. Bryant, Directing Chemist, Clinton Sugar Refining Company. Clinton, Iowa. American Food Jour. Vol. 12, No. 9. Sept. 1917. p. 512.



CORN PRODUCTS PLANTS IN THE UNITED STATES.

From P. W. Allen's Industrial Fermentations. N. Y. Chemical Catalog Co., Inc., 1926, p. 187.

Name of Firm.	Location.
Penick & Ford	Cedar Rapids, Iowa.
Clinton Sugar Refining Co.	Clinton, Iowa.
J. C. Hubinger Bros. Co.	Keokuk, Iowa.
Corn Products Refining Co.	Granite City, Ill.
" " " "	Pekin, Ill.
A. E. Staley Co.	Decatur, Ill.
Corn Products Refining Co.	Argo, Ill.
American Maize Co.	Roby, Ind.
Piehl Bros.	Indianapolis, Ind.
Union Starch Co.	Edinburgh, Ind.
Huron Milling Co.	Harbor Beach, Mich.
Keever Starch Co.	Columbus, Ohio.
Corn Products Refining Co.	Oswego, N. Y.
" " " "	Edgewater, N. J.
" " " "	Kansas City, Mo.

YIELD OF CORN PRODUCTS.

P. W. Allen. - Industrial Fermentations. N. Y. Chemical Catalog Co., Inc., 1926, p. 170-171.

"Yield of starch, feed and oil from one bushel of corn may be as follows:

	Theoretically	Practically
Starch	36.0 pounds	32.5 pounds
Feed:		
Gluten meal	7.0 pounds	9.0 pounds
Corn bran	5.0 pounds	7.0 pounds
Germ oil meal	2.2 pounds	2.0 pounds
Steep-water	4.0 pounds	4.0 pounds
Corn oil	1.8 pounds	1.5 pounds"

PRESENT USES OF CORNCOBS.

O. R. Sweeney. Iowa State College of Agricultural and Mechanical Arts. Iowa Engineering Exp. Sta. Bul 73. 1924. p. 8-10. Official Pub. Vol. 23, No. 15, Sept. 10, 1924.

"Present uses of corncobs. At the present time the corncob occupies a position so low in the industrial scale as to be considered almost worthless. There are a few well defined uses, however, some of which are nearly as old as corn itself.

"One of the best established uses is the manufacture of cob pipes by the mechanical shaping and finishing of selected cobs.

"Housewives extract a flavor similar to that of maple syrup from corncobs by boiling them in water and mixing the resulting syrup with glucose or cane sugar. ...

"The ground up cob is sometimes thrown on the rug or floor as an aid to the collection of dust and other material in sweeping. On rough wood floors the material is used, soaked with oil, to make it highly absorptive to dust.

"Cobs are used by farmers to some extent for 'smoking meat.' The meats to be cured are hung in a 'smoke house' where the smoldering cobs produce a thick white smoke which seems to compare very favorably with that from hickory wood in efficiency and in the flavor and brownness of the product. ...

"For centuries charcoal has been used in the feeding of animals as supplement to their ration. Charcoal prepared from corncobs has long been used for this purpose in Iowa and other corn belt states where stock is raised. ...

"Perhaps the most important present use of corncobs, at least with regard to the bulk consumed, is as a fuel. Cobs are burned in cook stoves and to some extent in heating stoves throughout the rural districts and towns in the corn belt. They burn with a long, clean, hot, flame, but the fire must be replenished frequently." ...

"Another use which has been suggested for corncobs and has been tried to some extent is a packing material for gas purification towers, to form a carrier base for purification materials such as iron oxide. ..."

CORN THE MAGIC CROP, YIELDS ENDLESS TREASURES.

E. V. Wilcox. The Country Gentleman. Vol. 87, No. 31. Sept. 9, 1922, p. 30.

"...We have been reminded that corn gives us pork, beef, mutton, fried chicken, eggs, milk, butter, cheese, johnnycake, hominy, flapjacks, hasty pudding, hot tamales, corn pone, and scores of other good things to eat. We have found that corn sweetens our candy and cakes, yields shortening for our bread and biscuits, gives filling for our pies and puddings, stiffens our collars, stains and varnishes our wood furnishings, helps to make ink and paper, sticks the stamps on our letters, holds briquettes together, sputters in fireworks, booms in explosives, dyes our calico, protects our battleships, softens our face powders, stops up bottles, rubs out our mistakes with art gum, and gives us salad oils, soaps, mattresses, pipes and music disks.

"Thus the magic corn plant feeds us, sings to us, washes us clean, hands us a pipe of peace, gives us abounding energy, and at the close of day provides us with a bed."

CRYSTALLIZED DEXTROSE FROM CORN STARCH.

C. B. Morison. Baking Technology, Vol. 3, No. 4, April, 1924, p. 118.

"One of the most interesting developments in the field of industrial sugar chemistry in recent years has been in the improvement of the process for the commercial production of a high purity crystallized dextrose from corn starch. Though various grades of dextrose or corn sugar have been on the market for many years, in solid 'lump' or 'chips' and a high purity dextrose is made on the laboratory scale, it is only within the last few years that the production of a white crystallized product in granular or powdered form has been commercially successful."

ARGENTINE CORN.

W. J. T. Duvel. U. S. Dept. of Agr. Farmers' Bul. 581. 1914. p. 9-12.

Considerable quantities of corn are being imported into the United States from the Argentine, most of which are consigned to the corn products manufacturing companies, for that reason it is of interest to know something of the physical and chemical characteristics of the Argentine Corn. A study of the quality, condition and chemical composition of Argentine Corn was made by the Department of Agriculture during the summer of 1912, December 1913, and January 1914. The following results were published in Farmers' Bulletin 581:

Quality and Condition of Argentine Corn.

"Corn as grown in the Argentine consists almost exclusively of the hard, flinty varieties with medium to small kernels, mostly yellow in color. The character of the corn, having both small cobs and small kernels, results in a much lower moisture content in the Argentine shelled corn than is normally contained in the large dent varieties of the United States. As a result of the small size of the kernels, the Argentine corn can not carry, without increased danger of deterioration, as high a percentage of water as the larger dent corns of the United States. On the other hand, the hard and firm texture of the Argentine corn is such that it can be 'conditioned' to much better advantage than our dent corns.

"During the summer of 1912, through the courtesies of the Corn Products Refining Co. and the grain-inspection department of the New York Produce Exchange, several cargoes of corn from the Argentine were examined at the time of discharge at the port of New York. The average results of mechanical analyses on 157 samples from four of the cargoes, representing a total of 638,000 bushels, are contained in Table 5. The data shown in this table represents new corn of the crop of 1912.

Table 5.- Average quality and condition of four cargoes of Argentine corn, crop of 1912, as discharged at New York.

Steamship	Date of arrival at New York.	Days in transit	Number of samples taken.	Bushels in cargo.	Moisture content.	Weight per bushel.	Sound corn.	Dirt chaff cob, etc.
	1912				Per cent	Pounds	Per cent	Per cent
A.....	Oct. 19	35	55	180,000	14.55	60.87	93.84	0.10
B.....	July 8	27	48	260,000	14.80	60.10	95.28	.17
C.....	Aug. 4	45	28	66,000	17.02	57.75	63.74	.28
D.....	Aug. 5	34	26	132,000	15.43	60.01	90.02	.17
Total.....			157	638,000				
Average of 4 cargoes.....					15.10	60.05	90.50	.16

Chemical Composition. Cont.

"From Table 5 it will be seen that the average moisture content of the total 638,000 bushels was 15.1 per cent, the weight per bushel more than 60 pounds, the percentage of sound corn 90.5, and the dirt, chaff, cob, etc., approximately one-sixth of 1 per cent.

"During the months of December, 1913, and January, 1914, samples to the number of 591 were secured from 16 different cargoes of Argentine corn as discharged at New York and at Gulf ports. The average moisture content of these samples (old corn of the 1913 crop) was 13.7 per cent, or 6.6 per cent less than the average moisture content of corn shipped from country stations in central Illinois during December, 1913, and January, 1914, the latter being new corn of the 1913 crop. From the standpoint of moisture content alone this represents a difference in value of approximately 5 3/8 cents per bushel, based on a New York price of about 70 cents per bushel, not giving consideration to the increased danger of deterioration of high-moisture corn. While the average moisture content of the Argentine corn is low, a considerable quantity is damaged, musty, sour, and heating when discharged. This is evidenced by the fact that of the 591 samples previously referred to, the maximum moisture content was 41.6 per cent, the minimum being 9.2 per cent.

"Attention is also called to the distinctly inferior quality and condition of the corn from Steamer C as shown in Table 5. This ship was twice delayed during transit as the result of accident and some of the corn was in the ship more than 60 days, and some of it had become sea damaged and ship damaged. Excluding three samples which showed a moisture content of 32.7, 34.8, and 37 per cent, the average for the cargo would be 14.9 per cent. ...

Chemical Composition.

"A wide diversity of opinion exists as to the chemical composition of Argentine corn as compared with the dent varieties of the United States. While the data available are not sufficient to justify the drawing of any definite conclusions, the results of the chemical analyses of a limited number of samples of Argentine corn as discharged at New York indicate that the Argentine corn is superior, from the standpoint of chemical composition, to our dent corn as loaded for export at our Atlantic and Gulf ports, as shown in Table 6.

"Table 6 shows the average results of the chemical analyses of 98 samples of Argentine corn, representing 4 cargoes with a total of 638,000 bushels of the crop of 1912, as discharged at New York, together with the average of the analyses of 129 samples of North American corn, representing two cargoes of the 1910 crop and two cargoes of the 1911 crop with a total of 910,146 bushels as loaded for export.

Chemical Composition. Cont.

Table 6.- Chemical composition of four cargoes of Argentine flint corn as discharged at New York and of four cargoes of North American dent corn as loaded for export, calculated to a water-free basis.

Item.	Argentine corn crop of 1912 as imported at New York.	North American corn crops of 1910 and 1911 as loaded for export.
	Per cent.	per cent.
Ash	1.72	1.43
Ether extract (oil)	5.52	4.07
Protein	11.01	9.81
Crude fiber	1.99	2.18
Pentosans	6.02	6.19
Invert sugar	.30	.38
Sucrose	1.08	1.13
Acid calculated as acetic	.33	.28
Undetermined	72.03	74.53

"From Table 6 it will be seen that the ether extract or oil was approximately 1.5 per cent greater in the Argentine corn than in the United States corn, while the protein was 1.2 per cent greater. In the consideration of these analyses it is necessary to note that they represent commercial corn and are therefore not comparable with the analyses shown in textbooks, which are based on selected, hand-shelled samples."

SELECTED LIST OF REFERENCES ON THE USES AND THE PRODUCTS MADE OF CORN

Compiled by C. Louise Phillips, Scientific Assistant, Grain Investigations, Bureau of Agricultural Economics, U. S. Department of Agriculture.
Rev. Mar. 1926.

U. S. DEPARTMENT OF AGRICULTURE PUBLICATIONS

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Characteristic proteins in high-and low-protein corn, by M. F. Showalter and R. H. Carr. (In American chemical society. Jour. v.44, no. 9, Sept. 1922, p.2019-2023)

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UNITED STATES DEPARTMENT OF AGRICULTURE
Bureau of Agricultural Economics
Grain Investigations.

Compilation
relating to

USES AND PRODUCTS MADE OF CORN

Supplements 1 and 2 to

USGSA-GI-31

BY

C. Louise Phillips, Scientific Assistant, Grain Investigations
and
E. G. Boerner, Grain Supervisor, In Charge, Grain Investigations.

Washington, D. C.
1926, 1929.

UTILIZATION OF THE CORN CROP.

U. S. Dept. of Agr. Crops and Markets, Vol. 3, Sup. 1. Jan. 1926. p. 8.

"A study of the utilization of the corn crops of 1923, 1924, and 1925, has been made by the United States Department of Agriculture to determine how much of the crop is actually husked for grain, cut for silage, and hogged down and cut for forage. Estimates of acreage, yield per acre, and production have been made for many years for the corn crop as a whole, regardless of its utilization, the estimated yield per acre being applied to the total acreage.

"In 1925, of a total corn acreage of 101,631,000 acres, 86,339,000 acres were utilized for grain; 3,916,000 acres for silage, and 11,376,000 acres were cut for forage or hogged down. The acreage of corn for grain in 1925 was 1,600,000 acres greater than in 1924, but 400,000 acres less than in 1923. The acreage of corn for silage in 1925 was 400,000 acres less than in 1924, and almost the same as the acreage in 1923.

"The amount of corn estimated to have been husked or snapped in 1925 is 2,416,000,000 bushels, which is 500,000,000 bushels greater than in 1924, but nearly 100,000,000 bushels less than in 1923. Production of silage was 31,000,000 tons in 1925, which is about a 10 per cent increase above the production in both 1924 and 1923.

"In 1924 considerable areas of corn went into silos because it was unfit for husking, being immature or frosted. The amount cut for forage was also increased materially because of the immaturity of the crop at the time of the first killing frost in the fall. The crops of both 1923 and 1925, on the other hand, were generally well matured.

"Corn for silage in 1923 yielded 7.3 tons per acre, in 1924 6.6 tons, and in 1925 8.0 tons.

"Corn for grain in 1923 yielded 28.9 bushels per acre, in 1924 the yield was 22.7 bushels and in 1925 it was 28.0 bushels per acre.

"The quality of the 1925 crop of corn is somewhat above average, but the moisture content at time of harvest was reported rather high in a number of States because of the wet weather and lack of sunshine. Drying out of corn was further retarded by weather conditions during November, but in December dry cold weather was helpful."

AMOUNT OF CORN PRODUCTS MANUFACTURED.

American Elevator and Grain Trade. January, 1926. p. 438. Editorial.

"...In 1924, a total of 557,160,516 pounds of corn sugar was manufactured. The association estimates that in 1926 the output could easily be raised to a billion pounds if the new demand is sustained.

"The refining companies manufactured also in 1924 a total of 1,195,770,198 pounds of corn syrup; 876,472,000 pounds of corn starch; 80,000,000 pounds of corn oil, and 500,000 tons of corn gluten feed. A total of 75,349,000 bushels of corn was ground in that year to make these products. In the year just closed the grind is estimated at 71,000,000 bushels.

FIFTY MILLION BUSHELS OF CORN USED TO MAKE CORNSTARCH.

U. S. Dept. of Agr. Official Record, Vol. 2, No. 47, Nov. 21, 1923, p. 3.

"The manufacture of cornstarch has grown to such proportions in the United States that the industry now consumes about 50,000,000 bushels of America's great crop each year. From each bushel of corn the average manufacturer makes 33 pounds of cornstarch, and in 1921 the 10 largest concerns made nearly 1,650,000,000 pounds of this product, which was more than 90 per cent of the total produced that year. This industry, which began in the United States in 1844, has been increasing greatly in recent years. By 1880 the factories had reached a productive capacity of 230,000,000 pounds and practically all of it was consumed here. By 1921 there were nearly 50 plants and $6,000,000 worth of the output was exported. These figures are from a report recently made by the Department of Agriculture as a result of an investigation.

"The department, through the Bureau of Chemistry, which enforces the food and drugs act, finds that cornstarch, with the possible exception of granulated sugar, is the least adulterated of all food products appearing on the markets. In addition to being used for food, it is also used for many technical purposes.

"In the food industry cornstarch finds its greatest use as the basis for the manufacture of corn sirup or glucose about one-half of that produced in 1921 having been used for that purpose. It is employed by confectioners in making gumdrops, by housewives and chefs in thickening sauces and making custards. Confectioners also use it for forms into which soft candy is poured in making bonbons. Large quantities are used in the manufacture of baking powder and pie fillers. It is also an important ingredient in cosmetics and pastes and is used to a limited extent in pharmaceutical preparations."

HISTORY OF THE MANUFACTURE OF CORN PRODUCTS.

Abstracted from article by I. B. Wagner. The Corn Products Industry. (In Trans. of the Amer. Institute of Chemical Engineers, Vol. 6, 1913. p.1-11.)

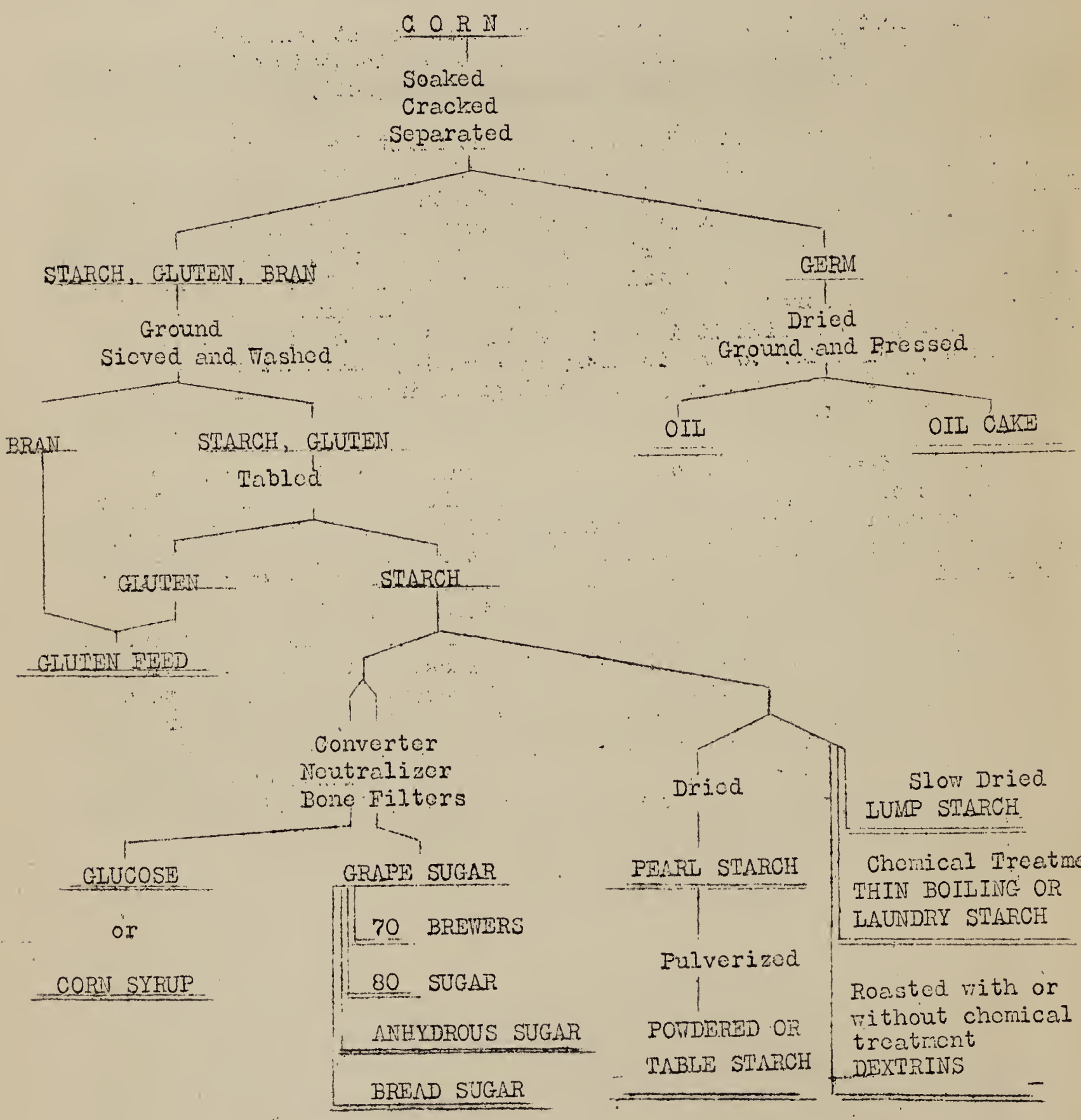
"The first product manufactured from corn was starch, and the first manufacturer was Thomas Kingsford, his plant being located at Oswego, N. Y. He commenced operations about seventy years ago." (1843)

The author states that "gluten" was the first by-product recovered in the manufacture of starch. Later the "bran" was recovered from the hull of the corn. In the course of time the manufacture of glucose was started and still later oil was recovered from the germ. Finally the chemist found a method of separating the glycerine from the fatty acids. The last waste product converted into an industrial commodity was the "steep water." It is collected, concentrated in vacuo, and added to the gluten feed in the form of a syrup with which it is subsequently dried - the feed acting as an absorbent. "Applied to the industry as a whole, this former waste -- ("steep-water") furnishes to-day an annual gross income of approximately 1 1/2 million dollars."

"...The development of our products occurred simultaneously, and to the series of bulk products were added, in the course of time, a large number of special products, such as thin boiling and modified starches, suitable for every conceivable technical purpose, dextrines and gums, special varieties of glucose, mixed table syrups, so-called '70' and '80' sugars, and refined, hydrogenated and vulcanized corn oils. There is every prospect of further additions to the present number. Products of corn, in one form or another, are consumed to-day in almost every industry, and they reach every corner of the civilized world. Figuratively speaking, this branch of efficiency was raised from 1 to 100 - that is to say, where originally the industry was based upon manufacture of only one product, to wit, corn starch, to-day the number of separate articles obtained from corn presents the formidable array of 100 products and more."

DIAGRAM SHOWING STEPS IN THE MANUFACTURE OF VARIOUS PRODUCTS FROM CORN.

Dr. A. P. Bryant, Directing Chemist, Clinton Sugar Refining Company. Clinton, Iowa. American Food Jour. Vol. 12, No. 9. Sept. 1917. p. 512.



CORN PRODUCTS PLANTS IN THE UNITED STATES.

From P. W. Allen's Industrial Fermentations. N. Y. Chemical Catalog Co., Inc., 1926, p. 187.

Name of Firm.	Location.
Penick & Ford	Cedar Rapids, Iowa.
Clinton Sugar Refining Co.	Clinton, Iowa.
J. C. Hubinger Bros. Co.	Keokuk, Iowa.
Corn Products Refining Co.	Granite City, Ill.
" " " "	Pekin, Ill.
A. E. Staley Co.	Decatur, Ill.
Corn Products Refining Co.	Argo, Ill.
American Maize Co.	Roby, Ind.
Piehl Bros.	Indianapolis, Ind.
Union Starch Co.	Edinburgh, Ind.
Huron Milling Co.	Harbor Beach, Mich.
Keever Starch Co.	Columbus, Ohio.
Corn Products Refining Co.	Oswego, N. Y.
" " " "	Edgewater, N. J.
" " " "	Kansas City, Mo.

YIELD OF CORN PRODUCTS.

P. W. Allen. - Industrial Fermentations. N. Y. Chemical Catalog Co., Inc., 1926, p. 170-171.

"Yield of starch, feed and oil from one bushel of corn may be as follows:

	Theoretically	Practically
Starch	36.0 pounds	32.5 pounds
Feed:		
Gluten meal	7.0 pounds	9.0 pounds
Corn bran	5.0 pounds	7.0 pounds
Germ oil meal	2.2 pounds	2.0 pounds
Steep-water	4.0 pounds	4.0 pounds
Corn oil	1.8 pounds	1.5 pounds"

PRESENT USES OF CORNCOBS.

O. R. Sweeney. Iowa State College of Agricultural and Mechanical Arts. Iowa Engineering Exp. Sta. Bul 73. 1924. p. 8-10. Official Pub. Vol. 23, No. 15, Sept. 10, 1924.

"Present uses of corncobs. At the present time the corncob occupies a position so low in the industrial scale as to be considered almost worthless. There are a few well defined uses, however, some of which are nearly as old as corn itself.

"One of the best established uses is the manufacture of cob pipes by the mechanical shaping and finishing of selected cobs.

"Housewives extract a flavor similar to that of maple syrup from corncobs by boiling them in water and mixing the resulting syrup with glucose or cane sugar. ...

"The ground up cob is sometimes thrown on the rug or floor as an aid to the collection of dust and other material in sweeping. On rough wood floors the material is used, soaked with oil, to make it highly absorptive to dust.

"Cobs are used by farmers to some extent for 'smoking meat.' The meats to be cured are hung in a 'smoke house' where the smoldering cobs produce a thick white smoke which seems to compare very favorably with that from hickory wood in efficiency and in the flavor and brownness of the product. ...

"For centuries charcoal has been used in the feeding of animals as supplement to their ration. Charcoal prepared from corncobs has long been used for this purpose in Iowa and other corn belt states where stock is raised. ...

"Perhaps the most important present use of corncobs, at least with regard to the bulk consumed, is as a fuel. Cobs are burned in cook stoves and to some extent in heating stoves throughout the rural districts and towns in the corn belt. They burn with a long, clean, hot, flame, but the fire must be replenished frequently." ...

"Another use which has been suggested for corncobs and has been tried to some extent is a packing material for gas purification towers, to form a carrier base for purification materials such as iron oxide. ..."

CORN THE MAGIC CROP, YIELDS ENDLESS TREASURES.

E. V. Wilcox. - The Country Gentleman. Vol. 87, No. 31. Sept. 9, 1922, p. 30.

"...We have been reminded that corn gives us pork, beef, mutton, fried chicken, eggs, milk, butter, cheese, johnnycake, hominy, flapjacks, hasty pudding, hot tamales, corn pone, and scores of other good things to eat. We have found that corn sweetens our candy and cakes, yields shortening for our bread and biscuits, gives filling for our pies and puddings, stiffens our collars, stains and varnishes our wood furnishings, helps to make ink and paper, sticks the stamps on our letters, holds briquettes together, sputters in fireworks, booms in explosives, dyes our calico, protects our battleships, softens our face powders, stops up bottles, rubs out our mistakes with art gum, and gives us salad oils, soaps, mattresses, pipes and music disks.

"Thus the magic corn plant feeds us, sings to us, washes us clean, hands us a pipe of peace, gives us abounding energy, and at the close of day provides us with a bed."

CRYSTALLIZED DEXTROSE FROM CORN STARCH.

C. B. Morison. Baking Technology, Vol. 3, No. 4, April, 1924, p. 118.

"One of the most interesting developments in the field of industrial sugar chemistry in recent years has been in the improvement of the process for the commercial production of a high purity crystallized dextrose from corn starch. Though various grades of dextrose or corn sugar have been on the market for many years, in solid 'lump' or 'chips' and a high purity dextrose is made on the laboratory scale, it is only within the last few years that the production of a white crystallized product in granular or powdered form has been commercially successful."

ARGENTINE CORN.

W. J. T. Duvel. U. S. Dept. of Agr. Farmers' Bul. 581. 1914. p. 9-12.

Considerable quantities of corn are being imported into the United States from the Argentine, most of which are consigned to the corn products manufacturing companies, for that reason it is of interest to know something of the physical and chemical characteristics of the Argentine Corn. A study of the quality, condition and chemical composition of Argentine Corn was made by the Department of Agriculture during the summer of 1912, December 1913, and January 1914. The following results were published in Farmers' Bulletin 581:

Quality and Condition of Argentine Corn.

"Corn as grown in the Argentine consists almost exclusively of the hard, flinty varieties with medium to small kernels, mostly yellow in color. The character of the corn, having both small cobs and small kernels, results in a much lower moisture content in the Argentine shelled corn than is normally contained in the large dent varieties of the United States. As a result of the small size of the kernels, the Argentine corn can not carry, without increased danger of deterioration, as high a percentage of water as the larger dent corns of the United States. On the other hand, the hard and firm texture of the Argentine corn is such that it can be 'conditioned' to much better advantage than our dent corns.

"During the summer of 1912, through the courtesies of the Corn Products Refining Co. and the grain-inspection department of the New York Produce Exchange, several cargoes of corn from the Argentine were examined at the time of discharge at the port of New York. The average results of mechanical analyses on 157 samples from four of the cargoes, representing a total of 638,000 bushels, are contained in Table 5. The data shown in this table represents new corn of the crop of 1912.

Table 5.- Average quality and condition of four cargoes of Argentine corn, crop of 1912, as discharged at New York.

Steamship	Date of arrival at New York.	Days in transit	Number of samples taken.	Bushels in cargo.	Moisture content.	Weight per bushel.	Sound corn.	Dirt chaff cob, etc.
	1912				Per cent	Pounds	Per cent	Per cent
A.....	Oct. 19	35	55	180,000	14.55	60.87	93.84	0.10
B.....	July 8	27	48	260,000	14.80	60.10	95.28	.17
C.....	Aug. 4	45	28	66,000	17.02	57.75	63.74	.28
D.....	Aug. 5	34	26	132,000	15.43	60.01	90.02	.17
Total.....			157	638,000				
Average of 4 cargoes.....					15.10	60.05	90.50	.16

Chemical Composition. Cont.

"From Table 5 it will be seen that the average moisture content of the total 638,000 bushels was 15.1 per cent, the weight per bushel more than 60 pounds, the percentage of sound corn 90.5, and the dirt, chaff, cob, etc., approximately one-sixth of 1 per cent.

"During the months of December, 1913, and January, 1914, samples to the number of 591 were secured from 16 different cargoes of Argentine corn as discharged at New York and at Gulf ports. The average moisture content of these samples (old corn of the 1913 crop) was 13.7 per cent, or 6.6 per cent less than the average moisture content of corn shipped from country stations in central Illinois during December, 1913, and January, 1914, the latter being new corn of the 1913 crop. From the standpoint of moisture content alone this represents a difference in value of approximately 5 3/8 cents per bushel, base on a New York price of about 70 cents per bushel, not giving consideration to the increased danger of deterioration of high-moisture corn. While the averag moisture content of the Argentine corn is low, a considerable quantity is damaged, musty, sour, and heating when discharged. This is evidenced by the fact that of the 591 samples previously referred to, the maximum moisture content was 41.6 per cent, the minimum being 9.2 per cent.

"Attention is also called to the distinctly inferior quality and condition of the corn from Steamer C as shown in Table 5. This ship was twice delayed during transit as the result of accident and some of the corn was in the ship more than 60 days, and some of it had become sea damaged and ship damaged. Excluding three samples which showed a moisture content of 32.7, 34.8, and 37 per cent, the average for the cargo would be 14.9 per cent. ...

Chemical Composition.

"A wide diversity of opinion exists as to the chemical composition of Argentine corn as compared with the dent varieties of the United States. While the data available are not sufficient to justify the drawing of any definite conclusions, the results of the chemical analyses of a limited number of samples of Argentine corn as discharged at New York indicate that the Argentine corn is superior, from the standpoint of chemical composition, to our dent corn as loaded for export at our Atlantic and Gulf ports, as shown in Table 6.

"Table 6 shows the average results of the chemical analyses of 98 samples of Argentine corn, representing 4 cargoes with a total of 638,000 bushels of the crop of 1912, as discharged at New York, together with the average of the analyses of 129 samples of North American corn, representing two cargoes of the 1910 crop and two cargoes of the 1911 crop with a total of 910,140 bushels as loaded for export.

Chemical Composition. Cont.

Table 6.- Chemical composition of four cargoes of Argentine flint corn as discharged at New York and of four cargoes of North American dent corn as loaded for export, calculated to a water-free basis.

Item.	Argentine corn crop of 1912 as imported at New York.	North American corn crops of 1910 and 1911 as loaded for export.
	Per cent.	per cent.
Ash	1.72	1.43
Ether extract (oil)	5.52	4.07
Protein	11.01	9.81
Crude fiber	1.99	2.18
Pentosans	6.02	6.19
Invert sugar	.30	.38
Sucrose	1.08	1.13
Acid calculated as acetic	.33	.28
Undetermined	72.03	74.53

"From Table 6 it will be seen that the ether extract or oil was approximately 1.5 per cent greater in the Argentine corn than in the United States corn, while the protein was 1.2 per cent greater. In the consideration of these analyses it is necessary to note that they represent commercial corn and are therefore not comparable with the analyses shown in textbooks, which are based on selected, hand-shelled samples."

SELECTED LIST OF REFERENCES ON THE USES AND THE PRODUCTS MADE OF CORN

Compiled by C. Louise Phillips, Scientific Assistant, Grain Investigations, Bureau of Agricultural Economics, U. S. Department of Agriculture.
Rev. Mar. 1926.

U. S. DEPARTMENT OF AGRICULTURE PUBLICATIONS

The agricultural situation in Hungary - corn (maize) (In Dept. Bul. 1234, Agricultural Survey of Europe: The Danube Basin - Part I, by L. G. Michael, 1924, p.19-22)

Argentine corn, by W. J. T. Duvel. (In Farmers' bul. 581, The Agricultural Outlook, 1914, p.9-12)

Comparison of corn oils obtained by expeller and benzol extraction methods, by A. F. Sievers, 1922. 20p. (Dept. bul. 1054)
"Literature cited": p.17-20.

Compilation relating to uses and products made of corn, by C. L. Phillips and E. G. Boerner. 1925. 21p. Mimeographed. (USGSA-GI-31)

Composition of corn (maize) meal manufactured by different processes and the influence of composition on the keeping qualities, by A. L. Winton, W. C. Burnet, and J. H. Bornmann. 1915. 31p. (Dept. bul. 215)

Corn and its uses as food. 1923. 27p. (Farmers' bul. 1236)

Corn cobs found to yield furfural. (In Weekly News Letter, v.7, no.42, May 19 1920, p.6)

Corn meal as a food and ways of using it, by C. F. Langworthy and C. L. Hunt. Rev. 1919. Reprinted 1921. 23p. (Farmers' bul.565)

Corn oil. (In Some American Vegetable Food Oils, Their Sources, and Methods of Production, by H. S. Bailey, in Yearbook, 1916, p.173-176) (Issued also as Separate 691, p.15-18)

Cornstarch manufacture expanding. (In Official Record, v.2, no.47, Nov. 21, 1923, p.3)

Elemental composition of the corn plant, by W. L. Latshaw and E. C. Miller. (In Jour. Agr. Research, v.27, no.11, Mar. 15, 1924, p.845-859)
"Literature cited": p.859.

How to select foods. II. Cereal foods, by C. L. Hunt and H. W. Atwater. 1917. 23p. (Farmers' bul. 817)

Preparation of an edible oil from crude corn oil, by A. F. Sievers and J. H. Shrader. 1922. 25p. (Dept. bul. 1010)

Production and conservation of fats and oils in the United States, by H. S. Bailey and B. E. Reuter. 1919. 48p. (Dept. bul. 769)

Production and utilization of corn oil in the United States, by A. F. Sievers. 1920. 23p. (Dept. bul.904)

Use for waste corn cobs. (In Weekly News Letter, v.6, no.36, April 9, 1919, p.14)

Uses made of the corn crop. (In Crop Reporter, v.15, no. 1, Jan. 1913, p.4; also in Monthly Crop Report, v.3, no.6, June, 1917, p.50)

[Uses of corn] (In the Corn Crop, by C. E. Leighty and others, in Yearbook, 1921, p.164-165) (Published also as Separate 872)

Utilization of the corn crop. (In Crops and Markets, v.3, Sup. 1, Jan. 1926, p.8)

Miscellaneous Publications

Acetone, butanol, and ethanol, in gas from the butyric fermentation of corn, by A. L. Davis. (In Industrial and Engineering Chemistry, v.15, no.6, June, 1923, p.631-632)

All made from King Corn. Chicago, American manufacturers' association of products from corn,n.d. 15p

Amazing story of corn. (In American Review of Reviews, v.70, no.5, Nov. 1924. p.552-553)

A bibliography of investigations bearing on the composition and nutritive valu of corn and corn products, by M. H. Keith. Washington, National research council, 1920. 178 numb. leaves. Mimeographed.

Building material from corn cobs. (In Chemical Age, v.30, no.11, Nov. 1922, p.515)

Cerelose in the bakery. Recent developments in the production of high purity crystallized dextrose from corn starch, by C. B. Morison. (In Baking Technology, v.3, no.4, April, 1924, p.118-119; no.9, Sept. 1924, p.277-278)

Characteristic proteins in high-and low-protein corn, by M. F. Showalter and R. H. Carr. (In American chemical society. Jour. v.44, no. 9, Sept. 1922, p.2019-2023)

Commercial utilization of corncobs, by O. R. Sweeney. Ames, 1924. 111p. Iowa State Col. Agr. and Mechanic Arts. Official publication, v.23, no.15, Sept. 10, 1924 - Engin. Exp. Sta. Bul.73).
Bibliography: p.91-111.

Corn and corn products used as food, by Lucile Wheeler. Urbana, 1917. 19p. (Ill. Univ. Col. Agr. Ext. Circ.9)
Issued in cooperation with the U. S. Department of Agriculture.

Corn and its uses. Chicago, American manufacturers' association of products from corn, n.d. 12p.

Corn and its uses. Ames, 1924. 4p. (Iowa. State Col. Agr. and Mechanic Arts. Ext. Dept. Home Economics, Bul.44)

Corn and the milling of corn, by C. W. Stanley. (In Scientific Agriculture, v.2, no.8, April, 1922, p.271-275)

A corn cob enthusiast. (In American Elevator and Grain Trade, v.41, no.8, Feb. 1923, p.548)

Corn cobs converted into lumber. (In Grain Dealers Jour. v.51, no.8, Oct. 25, 1923, p.553)

The corn cob as an insulating material, by E. R. Darling. (In Raw Material, v.5, no.3, April, 1922, p.97)

Corn is the wonder crop, by Gilbert Gusler. (In The Nebraska Farmer, v.68, no. p.243, 278, Feb. 13, 1926)

Corn oil an example of conservation by the chemist, by A. F. Sievers. (In Che ical Age, v.31, no.1, Jan. 1923, p.33-34)

Corn production and the marketing movement: production and distribution, consumption of corn, export, demand. (In U. S. Federal trade commission. Report on the grain trade. v.3: Terminal grain marketing, 1921, p.34-35)

Corn products. (In Allen, P. W. Industrial fermentations. N.Y., Chemical ca: log co., inc., 1926, p.168-204)
"References on corn products": p.195-198.

Corn products a vital market factor. (In Orange Judd Illinois Farmer, v.73, no.17, Sept. 1, 1925, p.409)

Corn sugar and corn syrup in ice cream manufacture, by W. P. Cutler. (In Crea ery and Milk Plant Monthly, v.9, no.6, June, 1920, p.52,54)

Corn syrup. How it is made and for what it is used. Clinton, Iowa, Clinton sugar refining co. [191 -] 7p.

Cornstarch industry. (In American Fertilizer, v.59, no.13, Dec. 29, 1923, p.46)

Corn starch in the textile industry. by W. R. Cathcart. (In Textile World, v.54, no.4, July 27, 1918, p.401,403)

[Diagram showing the] industrial uses of the corn plant. (In Crissey, Forrest. The story of foods. Chicago, Rand McNally & co. [1917] p.63)

Efficiency in chemical industries. The corn products industry, by T. B. Wagner. (In American institute of chemical engineers. Trans. v.6, 1913, p.1-11)
This article gives a history of the corn products industry in the United States.

Factory control in the manufacture of cornstarch and corn syrup, by A. P. Bryant. (In Jour. of Industrial and Engineering Chemistry, v.8, no.10, Oct. 1916, p.930-932)

Fermentation process for the production of acetic and lactic acids from corncobs, by E. B. Fred and W. H. Peterson. (In Jour. of Industrial and Engineering Chemistry, v.13, no.3, Mar. 1921, p.211-213)

Fermentation process for the production of acetone, alcohol, and volatile acid. from corncobs, by W. H. Peterson, E. B. Fred, and J. H. Verhulst. (In Jour. of Industrial and Engineering Chemistry, v.13, no.9, Sept. 1921, p.757-759)

Finding uses for the corn cob. (In American Elevator and Grain Trade, v.43, no.5, Nov. 1924, p.366-367)

Finding work for the corncob. (In Current Opinion, v.70, no.1, Jan. 1921, p.119-120)

Furfural from corncobs, by F. B. LaForge and G. H. Mains. (In Industrial and Engineering Chemistry, v.15, no.5, May, 1923, p.499-502; v.15, no.8, Aug. 1923, p.823-829; v.15, no. 10, Oct. 1923, p.1057-1060; v.16, no. 4, April. 1924, p.356-359)

Heat value of corn, by W. L. DeBaufre. (In Power, v.56, no.6, Aug. 8, 1922, p.212; also in American Society Heating and Ventilating Engineering. Jou: v.28, no.7, Oct. 1922, p.739-740)

Heating value of corn, by W. L. DeBaufre. (In American Society of Agronomy. Jour. v.15, no.1, Jan. 1923, p.1-6)

King corn, by E. S. Miller. Paper read before the Grain men's club of Omaha, Nebr., Feb. 20, 1925. (Published in pamphlet form) 15p.

Maize for cornflour, By H. Wenholz. (In Agricultural Gazette of New South Wales, v.34, no.11, Nov. 1923, p.788)

Maize: Production and utilization. (In International Review of the Science and Practice of Agriculture, n.s., v.2, no.2, April-June, 1924, p.368-375.

Making the corncob useful. (In Literary Digest, v.83, no.6, Nov. 8, 1924, p.82-84)

Manufacture of corn starch, corn syrup, and corn sugar, by A. P. Bryant. (In American Food Jour. v.12, no.9, Sept. 1917, p.511-515)

Manufacture of high-purity crystalline anhydrous dextrose (glucose), by C.E.G. Porst. (In International Sugar Jour. v.23, no.274, Oct.1921, p.575-576)

Many uses of corn. (In Va. Dept. Agr. and Immigration. Yearbook, 1920. (Bul. 148) p.41-42)

Minting prairie gold, corn the magic crop, yields endless treasures, by E. B. Wilcox. (In Country Gentleman, v.87, no.31, Sept. 9,1922, p.3-4,30)

The oil of maize. (Zea mays) ... by Harriet Winfield. Easton, Pa., The Chemical publishing co., 1899. 49p.
Thesis (Ph.D.) - Columbia University.
Bibliography: p.44-49.

ZPaper pulp from corncobs. (In Chemical and Metallurgical Engineering, v.32, no.13, July, 1925, p.620)

Possible uses of corncob cellulose in the explosives industry, by L. G. Marsh. (In Jour. of Industrial and Engineering Chemistry, v.13, no.4, April, 192 p.296-298)

Practical study of corn cob utilization, by F. B. LaForge. (In Paper, v.27, no.16, Dec. 22, 1920, p.15-18,32)

Preparation of xylose from corn cobs, by C. S. Hudson and T. S. Harding. (In American chemical society. Jour. v.40, no.10, Oct.1918, p.1601-1602)

Process of the manufacture of corn products. Chicago, American manufacturers' association of products from corn, n.d. 16p.

Products derived from corn cobs. (In American society of mechanical engineers. Jour. [now Mechanical Engineering] v.40, no.6, June 1918, p.496-497)

Shall the corn fields run our cars? the possibilities of snythetic fuels, and the source of the alcohol to make them, by R. G. Skerrett. (In Scientific American, v.123, no.12, Sept. 18, 1920, p.274-284)

Simultaneous production of pentosan adhesives and furfural from corncobs and oat hulls, by F. B. LaForge. (In Industrial and Engineering Chemistry, v. v.16, no.2, Feb. 1924, p.130-131)

United States export trade in corn sirup and corn sugar. (In Chemical and Metallurgical Engineering, v.24, no.11, Mar. 16, 1921, p.485)

Use cobs for threshing fuel, by G. G. McVicker. (In American Thresherman, v.26, no. 1, May, 1923, p.9)

SUPPLEMENTARY LIST OF REFERENCES ON THE USES AND PRODUCTS MADE OF CORN*

By C. Louise Phillips, Scientific Assistant, Grain Investigations, Bureau of Agricultural Economics, U. S. Department of Agriculture, February, 1929.

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America's golden corn crop. The fascinating story of this country's most important grain, by Earle W. Gage. (In Grain World, v. 100, no. 15, Nov. 21, 1928, p.13-15)

The author discusses the products obtained from the corn kernel.

Cash for cornstalks, cellulose mills in three states are using once waste farm products, by G. M. Rommell, il. (In Country Gentleman, v.93, no. 10, Oct. 1928, p.17,40-42)

Illustrated article which mentions work which had previously been done on the use of cornstalks for paper making and discusses the operation of the Cornstalk Products Company recently organized at Danville, Illinois. The author makes a comparison of wood and cornstalks as a source of cellulose.

Cellulose resources. II. Cellulose from field crops. III. Cost of field crops for cellulose, by G. M. Rommel. (In Industrial and Engineering Chemistry, v.20, nos. 6 & 7, June, July, 1928. p.587-591;-716-719)

Illustrated articles which discuss the yield of corn stover grown under different conditions, yield of cellulose as a by-product. Cost of cornstalks to the manufacturer and to the farmer; and different uses made of cellulose.

A revision of these articles was incorporated in Mr. Rommel's book, "Farm Products in Industry."

Chemistry of lignin; lignin from corn cobs, by Max Phillips. (In Journal American Chemical Society, v.49, no.8, Aug. 1927, p.2037-2040)

A technical article which gives the results of a chemical study of lignin from corn cobs. Literature on subject mentioned.

Corn cobs, by Arthur P. Chew. (In Better Crops with Plant Food, v.11, no.2, Aug. 1928, p.5-8,55-57)

Article telling of the investigational work done by the U. S. Bureau of Chemistry and Soils on products made from corn. Discussion of the use of lignin, furfural, pentosans and cellulose.

*This list of references supplements the one contained in USGSA-GI-31, Sup. "Uses and Products Made of Corn," issued by the Bureau of Agricultural Economics, U. S. Department of Agriculture. 1926.

Corn fiber, and its uses. A history of the discoveries and inventions of chevalier Aver von Welsbach. Patented in the United States, April 21, 1863. N. Y. Gray & Green, printers. 1865. 30 p.

An account of the history of the discovery of making paper from cornstalks, the help given by the Austrian government and the final successful results obtained by Chevalier Aver von Welsbach.

Corn products. (In P. W. Allen, Industrial fermentation, 1926. p.168-204. Bibl.)

An account is given of the processes for making starch, glucose, corn sugar, corn oil and corn bran and germ meal for feed. A list of references on corn products is appended also a list of patents concerning the manufacture of corn products.

Cornstalks as an industrial raw material, by Lionel K. Arnold, il. (In Agricultural Engineering, v.9, no.12, Dec. 1928, p.379-380)

Discusses the availability and desirability of using cornstalks for the production of lumber substitutes and describes process developed by U. S. Bureau of Standards in cooperation with the Iowa State College for converting wallboard from cornstalks.

Corn wastes. (In Science, v.67, no. 1728, Feb. 10, 1928, sup. 10-11)

Reviews report by O. R. Sweeney of Iowa State College to the Engineering Foundation on how cornstalks and cobs can be made into 300 useful products.

Crop plants for paper making, by C. J. Brand. U. S. Bureau of Plant Industry, Circ. 82. 1911. 10 p.

Discussion of experiments made by the Department of Agriculture in using different crop plants for making paper. This circular is printed on paper made from cornstalks, broom-corn stalks, rice straw. Each sheet of four pages is printed upon a different lot of paper, making a total of five kinds of paper in the circular.

Farm by-products of Iowa invite chemical engineering projects, by O. R. Sweeney. (In Chemical and Metallurgical Engineering, v.34, no. 1, Jan. 1927, p.27-28)

p.27: Corn as a chemical raw material.

Farm products in industry, by G. M. Rommel. N. Y. R. D. Henkle Co. 1928. 318 p.

The book is published on paper made from cornstalks. The binding of a limited edition is a composition of cottonseed hulls. The author devotes two chapters to corn as a source of cellulose. Chapter 7 discusses what cornstalks are worth to the manufacturer; chapter 8, what cornstalks are worth to the farmer; bibliography is appended.

How corn comes back to the farmer, by S. W. Long. (In Bureau Farmer (Pa. ed), v.2, no. 10, June 1927, p. 10)

Discusses uses made of corn in making oil, syrups, candies, dextrin, gum arabic, nitro-starch, etc.

How the cornstalk paper is made. The story of the Corn Belt's newest industry, by Herman Steen. (In The Prairie Farmer, v.100, no.50, Dec. 15, 1928, p.5, 30, 31, 33, 34)

An interesting account of the development of the paper-making industry from cornstalks at the Danville factory. This issue of the journal was published on cornstalk paper.

King corn's contribution to commerce, by Earl Harding. il. (In American Elevator and Grain Trade. v.47, no.4, Oct. 15, 1928, p.199-200)

Mr. Harding is manager of the Development Dept., Cornstalks Products Co. He discusses the reasons for the suitability of cornstalks as a paper making material and sums up the results of their investigations up-to-date. Illustrations show the outside and interior view of the plant.

Making artificial silk from cornstalks. (In Chemicals, v.29, no.7, Feb. 13, 1928, p.32-3)

The Dorner process and its operation in the Danville plant is discussed.

Making rayon from cornstalk cellulose; process of Dr. Dorner. (In Chemicals (Dyestuffs sec) v.27, April 25, 1927, p.20. Same in Chemical Age (Lond), v.16. May 14, 1927. Sup. p.37)

Manufacture of sirup from cornstalks. (In Chemical and Metallurgical Engineering, v.34, no.8, Aug. 1927, p.472)

Statement of the results obtained at the Minnesota Agricultural Experiment Station with the experimental plant for the making of sirup from cornstalks.

Minting prairie gold; corn the magic crop yields endless treasures, by E. V. Wilcox. (In Country Gentleman, v.87, no.31, Sept.9,1922. p.3-4, 30)

Story of the wealth of materials obtained from corn.

New sources of chemical wealth, by F. L. Darrow. il. (In St. Nicholas, v.55, no.12, Oct. 1928, p.998-1001)

The author tells of the "romance" of cellulose obtained from cornstalks and cotton-seed hulls and refuse from sugar cane.

New wealth from farm waste, by Wheeler McMillan. (In Popular Science Monthly, v.110, no.5, May, 1927, p.11-13)

The preparation of several useful substances from corn cobs, by F. B. La Forge and C. S. Hudson, (In Journal of Industrial and Engineering Chemistry, v.10, no.11, Nov. 1, 1918, p.925-927)

Detailed description of the preparation from corn cobs of adhesive gum, xylose, acetic acid, and glucose.

The production of gluconic acid by the Penicillium luteum-purpurpogenum group I, by O. E. May, H. T. Herrick, Chas Thorn, and M. B. Chruch. (In Journal of Biological Chemistry, v.75, no.2, Nov. 1927, p.417-422)

Bibliography.

Rayon from cornstalk cellulose. (In Chemical Age, v.17, no.411, May 14, 1927, p.37)

Discusses the Dorner process for the conversion of cornstalks into cellulose and why it is successful.

Reaping riches from farm refuse, by H. H. Slawson. il. (In Bureau Farmer, v.4, no.3, Nov. 1928, p.4-5, 28-31)

A popular article telling in a general way of the utilization of different farm wastes for industrial purposes.

Story of a grain of corn. Prepared by the Associated Corn Products Manufacturers. il. (In Price Current-Grain Reporter, v.99, no.7, Feb. 15, 1928, p.10)

Illustrated story which tells in a non-technical way about the various products made from the kernels of corn, viz., corn sugar, syrup, starch, oil, corn gluten feed, and an account of the products derived from these materials.

Synthetic lumber from cornstalks, by G. M. Rommel. (In Chemicals, v.30, no.1, July 2, 1928, p.29)

Mr. Rommel is a lecturer on the faculty of the Institute of Chemistry of the American Chemical Society. He says cornstalks contain fabulous wealth in cellulose.

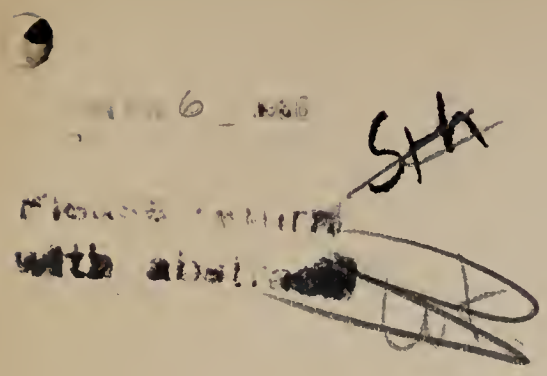
Treatment of packing house, tannery, and corn-products wastes, by F. W. Mohlman. (In Industrial and Engineering Chemistry, v.18, no.10, Oct. 1926, p.1076-81)

A report of the method used at Chicago for evaluating the effect of the industrial wastes of the packing houses, manufacture of corn products, and tanneries, and the results of the experimental treatment of these wastes.

The uses of corn, by C. Louise Phillips, il. (In Better Crops with Plant Food, v.9, no.2, July, 1927, p.10-12, 52)

Non-technical article on the various products made from the corn kernel, the cobs, and the cornstalks.

Utilizing the waste products; cotton burs, peanut shells, and cornstalks may be turned into building material, clothes, and fertilizers, by E. V. Wilcox. il. (In Farm and Ranch, v.47, no.43, Oct. 27, 1928, p.3)



UNITED STATES DEPARTMENT OF AGRICULTURE
Bureau of Agricultural Economics
Grain Investigations

Compilation
relating to

USES AND PRODUCTS MADE OF CORN

Supplement 3

Washington, D. C.
April, 1931.

C O N T E N T S

USES AND PRODUCTS MADE OF CORN

Compiled by C. Louise Phillips, Scientific Assistant, and E.G. Boerner, Senior Marketing Specialist, Grain Investigations, Grain Division.

CORN HARVESTED FOR GRAIN, FOR SILAGE, AND USED FOR HOGGING DOWN, GRAZING, AND FORAGE, 1929-1930

Compiled from Crops and Markets, December, 1930. Bureau of Agricultural Economics, U. S. Dept. of Agriculture.

The production of corn for grain in the United States in 1930 was estimated at 1,743,795,000 bushels, the smallest in any year since 1901. The yield in 1929 was 2,193,512,000 bushels. These estimates relate to corn husked, pulled, snapped or shredded, not corn for all purposes. The yield of corn for all purposes in 1930 was 2,081,048,000 bushels; in 1929 2,614,132,000 bushels were produced. The acreage of corn harvested for grain in 1930 was estimated at 84,701,000 acres; in 1929 the number of acres sown for grain was 82,668,000 acres, the smallest in any year since the estimates were begun in 1924.

The production of corn silage in 1930 was estimated at 28,956,000 tons. In 1929; 29,987,000 tons were produced. The acreage cut for silage in 1930 was 4,766,000 acres as compared with 4,306,000 acres in 1929.

There was an increase in the acreage of corn utilized for hogging, grazing, and forage in 1930 as compared with 1929 and 1928. A total of 11,363,000 acres was so utilized in 1930, as compared with 10,882,000 acres in 1929 and 10,974,000 acres in 1928.

ANALYSIS OF FOREIGN TRADE OF THE UNITED STATES IN CORN AND CORN PRODUCTS

Foreign Trade of the United States, 1790-1928. Corn and Corn Products. Caroline G. Gries, Bureau of Agricultural Economics, U. S. Dept. of Agriculture. Report F S 37. October, 1928.

p.1.Though the United States produces two thirds of the world's supply of corn, a comparatively small amount flows into the channels of foreign trade. In 1928 less than one per cent was marketed abroad. However, a very large per cent is exported as pork and pork products. Only twice during the last 25 years have United States exports amounted to more than 5 per cent of the crop and 1897 and 1899 were the only years on record in which they exceeded 10 per cent. Each year the domestic market absorbs larger and larger quantities and this fact together with the marked increase in production in Argentina largely accounts for the decline in our exports.

...In only two years,1906-and 1922, have exports exceeded 100,000,000 bushels.In 1925 the United States exported less than 10,000,000 bushels, the lowest figure since 1871.A large part of our surplus goes to the United King-

dom, Germany and the Netherlands. Canada and Cuba are also heavy purchasers.

p.2. Modern inventions and chemical analysis have greatly expanded the uses of corn and added to the value of the corn crop. Cornstarch, glucose, grape sugar, corn oil and corn oilcake are some of the products that have become important factors in our foreign trade. Cornstarch which is used in cooking, laundry work, in dressing and finishing textiles, in the manufacture of baking powder, candles and face powders is exported in heavy volume. Exports increased from 37,000,000 pounds in 1918 to 276,000,000 pounds in 1928, the peak of the export trade being reached in 1922 when foreign countries took 349,000,000 pounds.

p.2. Exports of glucose and grape sugar which are used to mix with sirups and in the production of jams, jellies, candy and chewing gum have increased from a little over 13,000,000 pounds in 1881 to nearly 146,000,000 pounds in 1928. Only once since 1909 have we exported less than 100,000,000 pounds. Exports of corn oil and corn oil-cake reached figures of considerable importance before the World War but since then have shown a decided decline. Such other corn products as hominy and grits, corn feeds and "Other corn preparations" are comparatively unimportant in our foreign trade.

WORLD TRADE IN CORN STARCH, AND AMOUNT AND VALUE OF CORN SIRUP, CORN SUGAR, AND CORN OIL PRODUCED IN 1929

Felix T. Pope, Foodstuff Division, Bureau of Foreign and Domestic Commerce, U. S. Dept. of Commerce. February, 1931

The corn starch industry is one of the industries that has developed very rapidly in recent years, and plays an important part in both our domestic and foreign trade. Production in the United States having increased from 311,100,000 pounds in 1904 to 1,046,168,459 pounds in 1929, the largest year in the history of the industry for which figures are available. No figures being available for 1930. Of the amount produced in 1929, 235,042,000 were exported. Exports for 1930 declined to 153,702,000 pounds. The decline in exports is largely due to the fact that on account of tariff restriction in certain foreign countries some of the larger American manufacturers have found it to their advantage to establish branch factories in foreign countries and are now supplying a considerable portion of their foreign trade from these branches. American manufacturers now have branch factories in Brazil, Argentine, Belgium, Czecho-Slovakia, Germany, France, Holland and possibly other countries.

The starch industry of the United States ground 86,620,041 bushels of corn in 1929. This is approximately 20 per cent of all of the so-called cash corn, that is, corn that comes into the market. The great bulk of our corn crop averaging about 2,850,000,000 bushels annually never leaves the farm, only about 450,000,000 bushels entering commercial channels.

These figures include only commercial corn starch sold as such, either in bulk or in packages and do not take into consideration starch that is used in the manufacture of glucose or corn syrup.

In the year 1929, the industry produced 1,157,698,336 pounds of corn syrup, valued at $40,553,180. 896,121,276 pounds of corn sugar, valued at $30,217,221. 170,459,407 pounds of corn oil, valued at $19,258,794 and various other miscellaneous products, such as oil cake and meal, gluten feed, etc., the total value of all products being $165,989,190 an increase of 25.4 per cent over 1927 (the last preceding census year)

The United States has a practical monopoly of the corn starch industry, it being the only country that produces this commodity in appreciable quantities. Although as stated before, some production is being developed abroad by American branch factories.

Canada produced about 28,000,000 in 1929, and about 105,000,000 pounds of other products. The total value of all products produced in 1929, being $5,504,685. This production, however, is not sufficient for Canada's needs and considerable quantities are imported from the United States, imports from this country for 1930 amounting to 4,500,000 pounds.

Corn starch is gradually replacing potato and other kinds of starch in the markets of the world. A bushel of corn (56 pounds) produces from 30 to 34 pounds of starch, while a bushel of potatoes (60 pounds) only produces about 9. As a result potato starch manufacturers cannot afford to use anything but "culls", which they pay about 15 cents a bushel for, the supply of these is not very large and therefore cannot keep much of an industry going.

Uses of Corn Starch:

Commercial corn starch goes into many different industries, and finds many uses -- The amount sold by grocers for food and home laundry purposes being the largest use in 1929, and the textile industry second.

(Detailed information showing the distribution of corn starch and corn sugar among the various trades may be secured from the Bureau of Foreign and Domestic Commerce, U. S. Dept. of Commerce)

Exports of Corn Starch:

Exports of corn starch for the year 1930, amounted to 153,702,000 pounds compared with 235,042,000 pounds in 1929. These exports went to over 70 different countries - to every port of the globe. The United Kingdom is by far our largest customer, having taken 106,496,000 pounds or about 69 per cent of the total. Other large customers were-

Japan	13,178,000 pounds
Philippines	8,142,000 pounds
Canada	4,499,000 pounds
British India	3,781,000 pounds
China	3,554,000 pounds
Cuba	2,880,000 pounds

(Details of exports of corn starch by countries of destination may be secured from the Bureau of Foreign and Domestic Commerce, U. S. Dept. of Commerce)

CORN SUGAR AND ITS USES

The Wet Milling Industry. VI. Corn Sugar and Its Uses. Geoffrey E. Govier. (In National Miller and American Miller, v. 58, no. 12, Dec. 1930. p. 22-23, 83-84)

"At the present time", the author says, "the greatest tonnage (of corn sugar) is consumed by the fermentation industries, artifical silk industry, baking industry, and the tanning industry".

The author discusses the following uses for corn sugar:

Fermentation industry:
- Alcohols
- Vinegars
- Lactic acid

Artificial silk industry:
- Used as reducing agent for copper

Baking industry:
- In bread dough
- Self-raising buckwheat and pancake flour
- Caramel coloring
- Ice cream
- Jams, jellies

Commercial mixed feed

Leather industry:
- Used in both vegetable and mineral or chrome tanning.

USING THE FARM BY-PRODUCTS

Science is Devising Many Ways to Utilize What was Formerly Agricultural Waste, and so Adding to the Farmers' Income

Arthur M. Hyde, Secretary of Agriculture. (In National Republic, v. 17, no. 3. July, 1929. p. 9-11, 40

p.9. ... Our chemical laboratories point out to us an age of cellulose, which challenges our imagination. What is cellulose? This is the substance - consisting of the three chemical elements carbon, hydrogen, and oxygen - which is the principal part of the solid frame work of plants. The wooden floors we walk upon, the newspapers and magazines and books we read, corn cobs, corn-stalks, wheat straw and other straws - these and myriad other things are largely cellulose. Chemically, cellulose is very similar in composition to corn-starch and the sugars; it contains the same elements and is convertible into sugars by the action of heat and acids.

Cotton is nearly pure cellulose. The chemist already knows how to make rayon and artificial silks out of cellulose from cotton linters, cornstalks, etc., and industries of great size have sprung up to manufacture them. Who can imagine the future in store for the humble and lowly cornstalk? I have seen a beautifully printed and bound book entitled "Farm Products in Industry," the paper of which was made mainly of cornstalks. I have read farm journals printed on paper, the most costly part of which had been replaced by cornstalk pulp. I have handled samples of insulating and building board made of cornstalks, some as porous and light as cork and some almost as hard and dense as iron. Who can say now, in view of the industrial beginnings already made, what part cornstalks, now worth $2 a ton for their potash and $3 as feed, will play in the building construction and heat and cold insulation of the future? Some day our books and daily news may come to use on cornstalk paper.

p.10. ...In the Bureau of Chemistry and Soils of our department in Washington, where a vast amount of valuable work has been done in the utilization of agricultural by-products, there is a small bottle of a brownish cellulose substance called lignin, which was derived from the corn plant. Lignin is one of the principal parts of woody plant tissues. Its chemical nature is not yet clear, but Dr. W. W. Skinner, assistant chief of the chemical and technological research unit of the bureau, says lignin possibly may yield as many products of commercial, chemical and medical importance as have been yielded by coal-tar, that by-product of the manufacture of coal gas, the study and exploitation of which gave to Germany a pre-eminent position in the world chemical trade. Our chemists say that lignin may possibly yield even more than coal-tar, itself a vegetable by-product of the carboniferous age. Some of the articles made from coal-tar that are of great commercial importance are aniline dyes, phy--thalein dyes and other phythaleins, indigo, carbolic acid, creosote, flavoring extracts and drugs and chemicals of many kinds. The Bureau of Chemistry and Soils has already made dyes from lignin which are more fast than the first aniline dyes from coal-tar. And the chemist has gone scarcely below the surface in the exploration of lignin. Millions and millions of tons of by-product stalks, cobs and straws are produced on our farms every year and every ton holds its store of the mysteries of lignin and cellulose - and who knows what else!

Then there is furfural, which is made an artificial resinous material -- a hard and quite elastic substance which when made from the corncob, looks almost exactly like gutta-percha. Gutta-percha is an imported product taken from Malaysian trees which is used for a multitude of purposes, especially as an insulator and non-conductor of electricity. Furfural can be made from a number of the woody cellulose by-products of the farm, corncobs and oat hulls being very good sources. Furfural may have tremendously extensive possibilities in the manufacturing industries. There is not yet a pressing economic or technical demand for the substance, but who knows when there may be? Our chemists believe the substance can be widely used some day in the manufacture of insulation materials, the parts of telephone instruments that are now hard rubber, penholders, umbrella handles and generally as a substitute for hard rubber, etc. There is a vast quantity of furfural in the cobs, hulls, straw and the like. One

One of the largest oat processing concerns in the country is now making large quantities of furfural from oats and selling it to manufacturers of resins, paints, lacquers, etc., who use it as a solvent. Furfural formerly was imported from Germany, as a chemical curiosity, at $30 a pound; today, as a result of work done by the Bureau of Chemistry and Soils, it is manufactured in this country to sell at about 11 cents a pound.

BY-PRODUCTS FROM FARM CHALLENGE U. S. CHEMISTS

Describing them as "by-products" of the farm, rather than by the more common term, "farm wastes," Dr. W. W. Skinner, of the United States Department of Agriculture, said in a recent address (March, 1931) that according to a careful estimate the United States produces annually more than 250,000,000 tons of these by-products, divided about as follows: Cornstalks 100,000,000 tons; cereal straws, 115,000,000 tons; corncobs, 20,000,000 tons; cotton stalks, 18,000,000 tons; oat hulls, 3,000,000 tons; flax straw, 2,200,000 tons; cottonseed hulls, 1,800,000 tons; sugarcane bagasse, 500,000 tons; and peanut hulls, 70,000 tons.

Doctor Skinner, who is assistant chief of the chemical and technological activities of the Bureau of Chemistry and Soils, says that these by-products of the important crops are composed approximately of cellulose, 40 per cent; lignin, 30 per cent; and hemicellulose, or carbohydrates, 30 per cent.

Cellulose is the material from which paper, rayon, and many other products are manufactured. It is possible at present to make paper pulp from a wide variety of crop by-products now wasted. But Doctor Skinner, who is thoroughly familiar with recent developments, says frankly that he does not know whether at present it is possible to make profitable use of cornstalks and straw.

These materials all have a certain basic value on the farm for fertilization and to provide organic matter for the soil. To this base cost the manufacturer must add the expense of collection, transportation, concentration, and usually storage. Increasing the size of a plant usually tends to reduce manufacturing costs, but it also tends to increase the average of the transportation costs for the bulky raw materials.

At this point the investigations of economists and engineers must supplement the findings of the chemists. Doctor Skinner is of the opinion that the only way to answer the question is by actual mill-scale production extending over several years. He points out that whether paper making from crop by-products will be profitable under any given circumstances would depend on a complex balancing of many factors, a few of the more important being the cost of wood pulp, the cost of transportation of raw materials and finished product whether these are derived from wood or from crop wastes, efficiency of manufacture, and relative cost of labor.

CORN-STALKS AND COBS IN INDUSTRY

L. K. Arnold, Engineering Experiment Station, Iowa State College
(In Science Monthly, v. 28, May, 1929. p. 463-470)

p.463. From hard, dense, strong material resembling polished ebony to a soft, spongy material resembling cork is the remarkable range of synthetic wood-like products produced from corn-stalks. ...

p.464. The corn-stalk insulating board is suitable as a substitute for lath and plaster, as a plaster base, or as sheathing either under wooden siding or under stone or brick veneer. It is an excellent heat insulator so that its use as a lining for refrigerators has been studied. Boards from 2 to 2⅛ inches in thickness have been built up by cementing or stitching together a suitable number of the 7/16 or 1/2-inch boards and by forming thick boards of a single layer on a special suction machine. Material equal to cork board in heat-insulation value has been produced and shown to be satisfactory substitute for the higher-priced material.

A hard dense type of board has been produced with the simultaneous application of heat and pressure in a special type of hydraulic press. This board resembles a very hard grainless wood and is suitable for many uses, such as paneling construction in Pullman cars, automobile bodies and truck bodies. Another type has been produced by pressing dry board under high pressures. This material resembles ordinary lumber. ...

But insulating board is only one of the things which can be made commercially from corn-stalks. Corn-stalks are now being used commercially in the production of excellent grades of paper. ... At Iowa State College the entire stalks have been made into paper without any attempt at separation of parts. Practically all the standard methods for producing paper pulp have been applied to corn-stalks in the laboratory. ...

p.466. By further purification of the paper pulp alpha cellulose can be produced. This is the raw material for rayon, or artificial silk, and is at the present time produced from wood and cotton. Experiments at Iowa State College showed that viscose could be produced from corn-stalk alpha cellulose, but due to lack of suitable equipment no extensive studies were made. Experimental work by a commercial organization in an eastern factory showed that high-grade rayon can be made by the three methods in common use in the United States.

The possibility of utilizing corn-stalks to replace wood as a raw material in the paper industry is of particular interest because of the rapidly decreasing supply of wood available in the United States...

p.467. Methods for harvesting of corn-stalks have been studied by the agricultural engineering department of Iowa State College. As a result of these studies a machine has been built which both cuts and bales the stalks as it travels through the field. This machine is a combination of a mower, a hay loader and a baler built into one machine drawn by a tractor. The stalks are cut by the mower, elevated from the

ground to a hopper over the baler by the hay loader, and baled in the baler. Two men are required to operate the machine. The cost of cutting and baling, including all items, is estimated at $2.40 per ton.

p.468. ...Like the corn-stalks the cobs have been the subject of extensive research by the chemical engineering department and Engineering Experiment Station. They have been destructively distilled, producing products similar to wood, as charcoal, acetic acid, formic acid, methanol, tar, illuminating gas and acetone. The charcoal has been shown to be an excellent feeding charcoal. After suitable treatment it forms an excellent decolorizing charcoal. As in the wood distillation industry the cobs are heated to a high temperature in a closed retort and the vapors condensed in suitable condensers.

It has been known for a long time that the pentosans, which are characteristic constituents of corn-cobs, could be utilized as a source of furfuraldehyde or, as it is commonly known, furfural. Extensive studies were carried on in the production of furfural from corn-cobs. The method worked out was to distill a mixture of dilute hydrochloric acid and ground corn-cobs. The vapor was condensed to a mixture of furfural and water which was fractionated to give almost pure furfural. Furfural, like formaldehyde, reacts to form a hard resin similar to bakelite. This resin may be used in production of certain varnishes, and, mixed with a suitable filler such as wood or corn-cob flour, as a molding resin. Instead of producing furfural from the cobs and then treating furfural with phenol, the plastic resin may be formed in the gound cobs by the addition of hydrochloric acid and phenol. The cellulose material of the cob remains in the resin, acting as a filler. The result is a low-grade plastic produced at a considerably lower cost than is possible by the other method.

Furfural has excellent preservative properties, having been used in veterinary embalming fluid, in the antiseptic treating of seeds, and for other similar purposes. Furfural and some of its derivatics are excellent solvents for nitrocellulose acetate. It is an excellent varnish remover. It was used in "dope" for airplane wings during the war. A number of dyes and anesthetics were prepared from furfural in the chemistry department of Iowa State College. Various furfural derivatives are excellent accelerators for use in the curing of rubber. Furfural can be used to replace gasoline, although at the present time it is too expensive for this purpose.

p.470. When corn-cobs are digested under pressure in water a strong adhesive can be produced. If dilute mineral acid is added a solution of xylose can be produced. Xylose is a sugar which up to the present time has been produced in large quantities only as a syrup. Since xylose has practically no food value it probably can be used by diabetic patients without the harmful effects produced by cane or beet sugar.

Oxalic acid has been produced in the laboratory by fusing corn-cobs with caustic soda and also by oxidizing corn-cobs with nitric acid. Considerable experimental work was done on the softening of water by using the impure corn-cob-alkali fusion mass direct without separating out the oxalic acid.

Various other uses have been found for corn-cobs. They have been ground to a flour which may be substituted for wood flour in many uses. It has been made into very good punk and incense. Ground cobs have been used in curing concrete floors in place of sawdust and have been substituted for bran for removing the oil from tin plate in the tin-plating industry. Corn-cobs have been used successfully in bee-smoking and in smoking of meats.

MANUFACTURE OF INSULATING BOARD FROM CORNSTALKS

O. R. Sweeney and W. E. Emley. U.S. Dept. of Commerce, Bureau of Standards, Miscellaneous Publication No. 112. 1930. 27 p.

This bulletin gives detailed data about the location and quantities of cornstalks available, the physical and chemical composition of the stalks and the parts thereof, and the methods and costs of harvesting and baling the stalks and delivering them to the factory. The authors describe the experimental work on the manufacture of insulating board from cornstalks, from the first laboratory experiments through the semi-commercial production, and give details of different ways of making pulp from cornstalks and different types of equipment used to make board from the pulp. Test methods and specifications showing quality of the board produced as compared with similar products are given. The authors estimate in detail the capital and operating costs for a commercial factory. An analysis is given of the present and probable markets for insulating board.

p.6. The cheapest method of harvesting the corn plant "was found to be that in which the corn was picked and the stalks shredded by a harvester consisting of a 2-row picker, with low cutting and shredding attachments, operated by a 30 h.p. motor. The shredded stalks were deposited in windrows on the field. When this machine was owned and used cooperatively by three farmers, the crop was harvested at a cost of $4.29 per acre, or, allowing $2.40 per acre for the cost of picking the corn, the cost of shredding the stalks and collecting them in windrows was $1.89 per acre. The stalks must then be raked up and baled to prepare them for transportation to the factory.

p.7. When considering the industrial utilization of cornstalks it is usually predicated that the factory shall be so located as to be able to get its annual supply of raw material within a 5 or 10 mile radius. Under such conditions railroad transportation will not be generally required. The cost of motor transportation for short hauls as an average for all kinds of roads is given as 8½ cents per ton-mile. By means of a tractor with trailers 11 tons of cornstalks have been hauled in one load.

MANUFACTURE OF INSULATING BOARD FROM CORNSTALKS
(Continued)

A study was made of putting the laboratory process which had been worked out at the Iowa State College into semicommercial production in order to ascertain by experiment the type of equipment best adapted to the purpose, the yield which might be expected, and the probable cost of manufacture.

p.9. The general procedure includes the following processes: The stalks are first shredded, then beaten to a pulp with a decided excess of water. After the pulp has been washed, and the sizing material added, it is picked up on a wire screen, which removes most of the water. The sheet of pulp is then passed through a press, which squeezes out more of the water and compresses the sheet to the desired thickness. The sheet then passes through a continuous drier and is cut into the desired lengths, or the sheet may be cut into lengths before the final drying operation.

These different process/es are described in detail.

The authors summarize their findings in the following sentence:

p.20. It is evident from the above that an insulating board can be made from cornstalks with about the same properties as those of similar boards made from other kinds of raw materials.

The equipment necessary from time the cornstalks enters the factory:

Bale-handling equipment and conveyors to move the bales from the stock pile to the factory; a magnetic separator to remove pieces of tramp iron which might damage the equipment; 1 large shredder; four 1-ton Hollander beaters; 1 stock chest, capacity 27,000 gallons; 1 mat-forming machine, 5 feet wide by 8 feet in circumference; 1 board-forming machine, 20 feet long, equipped with five pairs of rolls each 3 inches diameter by 4 feet long; 1 continuous single deck drier, 7 feet wide by 1,100 feet long; 1 automatic cutter and trimmer; the necessary pumps, skids, trucks, motors, and shafting; the necessary storage space for finished board; a railroad siding.

p.23. From estimates obtained during 1928 the cost of this equipment erected in place will be about $215,000. This figure must, of course, be taken as informative and not absolute, since the prices of machinery change with time and with the location selected for the factory. This equipment will require 47,250 square feet of floor space.

To operate the above equipment the following men will be required per shift:

Two men to handle the bales into the factory; 1 man to operate the shredder; 1 man to operate the beaters; 3 men to operate the mat-forming machine, board-forming machine, and drier; 8 men to handle the finished boards and load cars; total,15 men and 1 foreman per shift; or 45 men and 3 foremen per day.

A discussion of the power necessary - the raw material and output and overhead charges follow in the bulletin.

The authors say:

p.24. A careful analysis of the figures at hand leads to the belief that under the proper conditions insulating board can be made from cornstalks at a reasonable profit to both the manufacturer and the farmer.

MAIZOLITH (A CELLULOSE PRODUCT) FROM CORNSTALKS AND CORNCOBS

U. S. Dept. of Commerce, Bureau of Standards, Misc. pub. 108. 1930. 10 p.

The chemical engineering department at Iowa State College in cooperation with the United States Bureau of Standards have been working for several years on the utilization of farm wastes. The purpose of the work recorded in this publication was to determine the optimum conditions for the production of maizolith (a cellulose product made from corn cobs and cornstalks), to make a study of its properties, and to get an idea of the cost of producing the material. Maizolith is somewhat heavier and stronger than the hardwoods, and is a good electrical insulator. An abstract of the publication follows:

Maizolith is a dense, hard, bonelike substance made by cooking cornstalks or corncobs with caustic soda, washing the residue, beating it to a jell, and drying. The finished product has a modulus of rupture of about 16,000 lbs./in.^{2} and a volume resistivity of 3×10^9 ohms/cm^3. It is practically unaffected by oil, but becomes soft on prolonged soaking in water.

The optimum conditions for the manufacture of maizolith were found to be those indicated by the following process: Digest the shredded cornstalks three hours at 40 pounds pressure with 10 per cent of their bone-dry weight of caustic soda; dilute to a 1 per cent solution; wash free of cook liquors; dilute the pulp to a consistency of 4 per cent, beat for two hours in a combined beating engine and Jordan refiner and dry at a temperature of 70°C.

Cost figures for the process indicate that in a plant large enough to produce 5 tons per day, finished maizolith can be made for about $240 per ton, using cornstalks as the base material.

Maizolith could probably be made at a lower figure than $240 per ton as a by-product of the insulating wall board industry, by utilizing fibers or pith particles which are too fine or too highly hydrated to be used in insulating board.

By utilizing the soft residue from the process of extracting adhesive material from corncobs maizolith could probably be produced at a lower figure than that from either of the processes outlined above.

SOLVENTS - THEIR MANUFACTURE AND THEIR USES

How Solvents are Made from Corn, Oil and Water. (In Chemicals, v. 34, no. 5, August 4, 1930. p. 27-28)

This is a discussion of the manufacturing process of the products made from corn by a large corporation - acetone, and its derivatives, ethyl alcohol, denatured, and methanol, synthetic.

The author also discusses the uses made of these different products. He says: "Butanol ... finds its largest uses in the manufacture of lacquer, but butanol and its compounds are employed in more than 40 other industrial processes ranging from the refining of oils to the manufacture of textiles and dyestuffs.

Acetone serves a diversity of purposes. The artificial silk industry, the manufacture of photographic film, storage of acetylene, certain processes of oil refining and welding of steel and the extraction of oils all require acetone.

Diacetone alcohol, a derivative of acetone, is used in the manufacture of shoes, in hydraulic braking systems, and in finishes for artificial leather.

Ethyl alcohol, denatured, is an essential in almost all chemical and pharmaceutical manufacturing processes, and is the basic material for such products as ether and ethyl acetate.

Methanol is a product of great industrial importance. It is the basic material for the manufacture of formaldehyde and so finds its way into synthetic resins. ...

PRODUCTION OF FUEL GAS BY ANAEROBIC FERMENTATIONS

A. M. Buswell, Illinois State Water Survey Division. (In Industrial and Engineering Chemistry, v. 22, no. 11, Nov. 1930. p. 1168-1172)

This paper traces the early studies of production of methane by anaerobic fermentation; and summarizes recent work in that field. The chemical reactions involved in the decomposition of fats, proteins, and carbohydrates by anaerobic bacteria are discussed. A general formula is proposed for the reaction of the acids of the aliphatic series, and data are presented to show that the fermentations described result in a 90 per cent conversion of the material used into stoichiometric yields of carbon dioxide and methane. The commercial possibilities of the use of this fermentation process for the production of power gas from waste material are pointed out.

The author concludes his article by saying: "It is believed that the completion of some development work now in progress will make it possible for farms and ranches to install digestion tanks in which various crop residues may be converted in considerable amounts to a gaseous fuel of high heat value. The undigested residue could be composted and returned to the soil. The operation can be combined with other routine farm work in such a way that the cost of the gas should compare favorably with city gas prices.

It is also probable that small towns located in the corn belt could be supplied with gas in the same way. In this case the undigested residue would be baled and shipped to a nearby wallboard or paper mill.

As our coal, oil, and gas supplies become exhausted the installation of pipe lines fed by fermentation plants located along them at short distances would seem the most probable line of development.

The author says, "The present estimate is that from 5 to 10 cubic feet of gas can be obtained per pound of cornstalks, and that the rate of production will be from $\frac{1}{2}$ to 1 cubic foot of gas per day per cubic foot of tank volume. Taking the lower figure, a ton of cornstalks would furnish gas for 400 people for one day, allowing 25 cubic feet per day. From the data given by Webber for yields from regions where 30 per cent of the land is planted to corn, an area with an 8-mile radius will produce enough cornstalks to supply a city of 80,000 inhabitants with gas continuously. In other words, the cornstalks from one acre will produce the gas for one person for a year. Naturally, the bacteria require some nitrogen, and this may be supplied from domestic wastes."

BY-PRODUCTS FROM CORN-MASH

Some Observations on Beer Slop Waste from Corn-mash Distillation, W. D. Hatfield. (In Industrial and Engineering Chemistry, v. 22, March, 1930. p. 276-277)

The study presented in this paper was undertaken to determine the probable effect on sewage-disposal processes of the "beer slop" resulting from the operation of a large butanol manufacturing plant in Illinois.

In this process for the manufacture of butanol and other solvents about 20,000 bushels of corn a day are ground and cooked to a fine mash, cooled, fermented with especially prepared cultures, and distilled. The distillate contains the valuable solvents and the residue is called "beer slop". This residue amounts to over 125 million gallons per day.

The results of the study show that "the cost of treating such a strong waste makes its recovery as a by-product within the industry necessary and advisable."

METHANOL FROM CORN FERMENTATION GAS

Synthesizing Methanol from By-Product Gases: (In Chemical and Metallurgical Engineering v. 37, Sept. 1930. p. 548-549)

This article describes the process for the production of methanol from corn fermentation gas.

The corn was fermented for the production of acetone, butanol, and ethyl alcohol in a modern plant at Peoria, Illinois. A by-product of this fermentation wa a very large volume of gas consisting approximately of 40 per cent hydrogen and 60 per cent carbon dixoide by volume.

UNITED STATES PATENT LITERATURE RELATING TO THE UTILIZATION OF CORNSTALKS FOR PAPER MAKING

Joseph Rossman, Patent Examiner, U. S. Patent Office. (In Paper Trade Journal, v. 91, no. 23, Dec. 4, 1930. p. 51-54)

The article reviews the patent literature relating to the utilization of cornstalks for paper making. The author says that "a study of the patent literature indicates that over seventy-five years ago it has been proposed to use cornstalks for making cellulose. Many patents have been granted for methods of treating cornstalks, but apparently no process has yet been devised which can commercially displace wood as a major source of supply for cellulose."

The article includes a list and abstracts of the patents covering methods for treating cornstalks for paper making.

PATENTS

Production of lactic and acetic acids. W. H. Peterson and E. B. Fred. U. S. Patent 1,723,298. Patented Aug. 6, 1929. U. S. Patent Office, Washington, D. C.

The invention relates to the production of lactic acids from such waste material as wood, sawdust, straw, corncobs, corn stover, cottonseed hulls, by a heretofore unisolated microorganism.

Fermentation of cellulose. Herbert Langwell. U. S. Patent 1,443,881. Patented Jan. 30, 1923. U. S. Patent Office, Washington, D. C.

The patent covers an invention of the conditions under which the fermentation of cellulose is conducted.

Fermentation of cellulosic materials. Herbert Langwell. U. S. Patent 1,602,306. Patented Oct. 5, 1926. U. S. Patent Office, Washington, D. C.

The object of the invention is to provide improved processes for the fermentation of cellulose or cellulosic material, these improvements lying in the direction of control, efficiency, yield of desired products.

ADDITIONAL REFERENCES

Attempted correlations of constitution with sweet taste in the furan series. The very high sweetening power of 5-Benzyl-2-furfur-aldoxine. Henry Gilman and J. B. Dickey. (In Jour. American Chemical Society, v. 52, 1930. p. 2010-2013)

Cellulose from cornstalks. H. A. Webber. Dept. of Chemical Engineering, Iowa State College. (In Indus. and Eng. Chemistry, v. 21, no. 3, March, 1929. p. 270-275)

The article briefly summarizes the results of studies made on cornstalks by the joint cooperation of the United States Bureau of Standards, the Engineering Experiment Station, and the Agricultural Engineering and Chemical Engineering Departments of Iowa State College. The studies were made to ascertain if the cellulose obtainable from cornstalks is satisfactory enough, both in quality and quantity to make it a profitable source of raw material.

Chemistry of lignin. Lignin from corn cobs. Max Phillips, (In Amer. Chemical Society, v. 49, no. 8, August, 1927. p. 2037-2040)
Reports the results of a chemical study of a lignin fraction from corn cobs.

Chemistry of lignin. Franctional extraction of lignin from corn cobs. Max Phillips, U. S. Bureau of Chemistry and Soils. (In Jour. American Chemical Society, v. 50, July, 1928. p. 1987)
Lignin was fractionally extracted from corn cobs by a 2% alcoholic sodium hydroxide solution at room temperature, by 2% aqueous sodium hydroxide at 100° and at 135°, and finally by 4% aqueous sodium hydroxide at 180°. The results are recorded in this paper.

Chemistry of lignin. The destructive distillation of lignin from corn. Max Phillips, U. S. Bureau of Chemistry and Soils. (In Jour. American Chemical Society, v. 51, Aug. 1929. p. 2420-2426)
The lignin prepared from corn cobs by the alkali method, the fuming hydrochloric acid method of Willstatter and by the 72% sulfuric acid method was subjected to a destructive distillation under ordinary atmospheric pressure and at a temperature of 380° to 400°. The results are recorded in this paper.

Chemistry of lignin. The distillation of alkali lignin with zinc dust in an atmosphere of hydrogen. Max Phillips, U. S. Bureau of Chemistry and Soils. (In Jour. American Chemical Society, v. 53, no. 2. Feb. 1931. p. 768)
The investigation described in this article was undertaken to throw some light on the chemistry of lignin.

Corn cobs yield an intense new sweet, a perfume and an anesthetic. (In Scientific American, v. 141, July, 1929. p. 68)
Reviews work of Dr. Henry Gilman and A.P. Hewlett of Iowa State College in evolving a compound 300 times as sweet as sugar, a perfume, and an anesthetic.

Disposal of industrial waste; wastes from corn products and paint and dye works. F.W. Mohlman and A.J. Beck. (In Indus. and Eng. Chemistry, v. 21, March, 1929. p. 205)
Reports the results of intensive studies made of the wastes from a corn products refining company. Processes for recovering wastes are discussed in this article.

Fermentation of products from cornstalks. C. S. Boruff and A. M. Buswell. (In Indus. and Eng. Chemistry, v. 22, no. 9, Sept. 1930. p. 931-933)

Manufacture of starch, dextrine and British gum and their uses. Harry A. Croun. (In American Dyestuff Reporter, v. 19, no. 2. Feb. 3, 1930. p. 83-89)

This is a paper given before the American Association of Textile Chemists and Colorists, November, 1929. The author discusses the processes of separating the corn kernel in its various components and the manufacture of starch, dextrine and British gum, and the industrial application of these products.

Methane produced by digestion of corn stalks. Gas suitable for power production. Engineering News-Record, v. 104, no. 11, p. 445. March 13, 1930.

Reviews studies made by A. M. Buswell, of the Illinois State Water Survey, in the production of gas from sewage sludge-digestion, by the addition of cellulose material such as corn-stalks.

On the trail of a new source of energy. A. M. Buswell. (In Jour. of Western Society of Engineers, v. 34, no. 2, April, 1930. p.81-91)

Dr. Buswell discusses the experiments which have been made at Illinois University in releasing energy from waste organic matter (cornstalks) by the action of bacteria with the production of various products, principally, methane and carbon dioxide. Cornstalks were used in the experiments.

The Physical structure of cornstalks and wheat straw. R. E. Lofton, associate physicist, U.S. Bureau of Standards, Dept. of Commerce. (In Paper Trade Journal, July 31, 1930. p. 39-44)

This paper describes the physical structure of cornstalks and wheat straw. Its purpose is to give those interested in the utilization of the cereal crop wastes a better understanding of their physical and microscopical characteristics. Structural characteristics are illustrated by drawings and photo micrographs. For the purpose of comparison, photomicrographs and dimensions of four kinds of chemical wood fibers of industrial importance, two conferous and two deciduous, are given.

Preparation of some perfumes and flavoring extracts from furfural and its derivatives, Esters of B-Furylacrylic acid. Henry Gilman and G. F. Wright. (In Iowa State College Jour. of Science, v. 3, no. 2, 1929. p. 109-112)

Production of insulating board from cornstalks. C. E. Hartford. (In Indus. and Eng. Chemistry, v. 22, no. 12. Dec. 1930. p. 1280-1284)

The author writes on the following subjects:
Commercial development of cornstalk insulating board.
Collection of raw material.
Preparation of cornstalk pulp.
Forming, pressing, and drying the board.
Prospective developments.
Properties of cornstalk board.
Area distribution of cornstalk supply.
List of references at end of article.

Production of synthetic lumber from cornstalks. O. R. Sweeney and Robley Winfrey, Engineering Experiment Station, Iowa State College. (In Mechanical Engineering, v. 52, no. 9, Sept. 1930. p. 849-851)

The authors describe the work that has been done at Iowa State College in making wood substitutes from cornstalks and other agricultural wastes as synthetic lumber, substitute for balsa wood, acoustic board and cork substitute.

Some correlation of constitution with sweet taste in the furan series. Henry Gilman and A. P. Hewlett. (In Iowa State College Jour. of Science, v. 4, no. 1, 1929. p. 27-33)

Harvesting cornstalks for industrial uses. J.B. Davidson and E. V. Collings. (Iowa Sta. Bul. 274, pp. 373-394, 18 figs. Nov. 1930.)

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UNITED STATES DEPARTMENT OF AGRICULTURE
Bureau of Agricultural Economics
Grain Division

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USES AND PRODUCTS MADE OF CORN

ABSTRACTS AND REFERENCES

Supplement 4

—O—

Compiled by

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and
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Washington, D. C.
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USES AND PRODUCTS MADE OF CORN: ABSTRACTS AND REFERENCES

By C. Louise Phillips and E. G. Boerner, Grain Division, Bureau of Agricultural Economics, United States Department of Agriculture.

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INTRODUCTION

There is considerable interest in agricultural, commercial, and scientific fields in the subject of the utilization of corn. The United States Department of Agriculture, the United States Bureau of Standards, and several of the Agricultural Experiment Stations have been carrying on investigations relating to uses which may be made of, and the products that are made from, the entire corn plant - the kernel, the cob, and the stalk.

Several years ago a compilation of abstracts of reports and published material was made which brought together into one mimeograph pamphlet the results of many of the more important investigations on the subject. Three supplements have since been prepared and published from time to time, - the last one in 1931. This supplement, No. 4, contains abstracts and a list of references of many of the articles and reports that have been published since 1931. It has been prepared primarily for use in replying to the many requests for the results of recent studies which have been made on the utilization of corn and the corn plant.

CORN UTILIZATION

U. S. Department of Agriculture, Bureau of Agricultural Economics.
December, 1933.

Below are estimates of corn utilization, including the grain equivalent of corn hogged off or fed as silage, for the mentioned uses, in two selected periods, 1910-1914 and 1924-1929. Data in each case apply only to the first use of corn. The consumption figures for the various species of livestock on farms include the whole corn grain, cracked or ground corn if processed and fed on the farm, corn silage, and corn hogged off, all in terms of corn grain, but do not consider the corn by-products resulting from the merchant milling or corn mixed with other ingredients in making commercial feeds. The "industrial and commercial utilization" figures are made up of corn used in the production of alcohol, spirits, fermented beverages, breakfast foods, mixed feeds, and that utilized by the wet-and dry-process millers. The exports are of both corn grain and cornmeal, with the latter converted into the equivalent of corn grain. Exports of cornmeal were deducted from the "industrial and commercial utilization" data in order to avoid duplication.

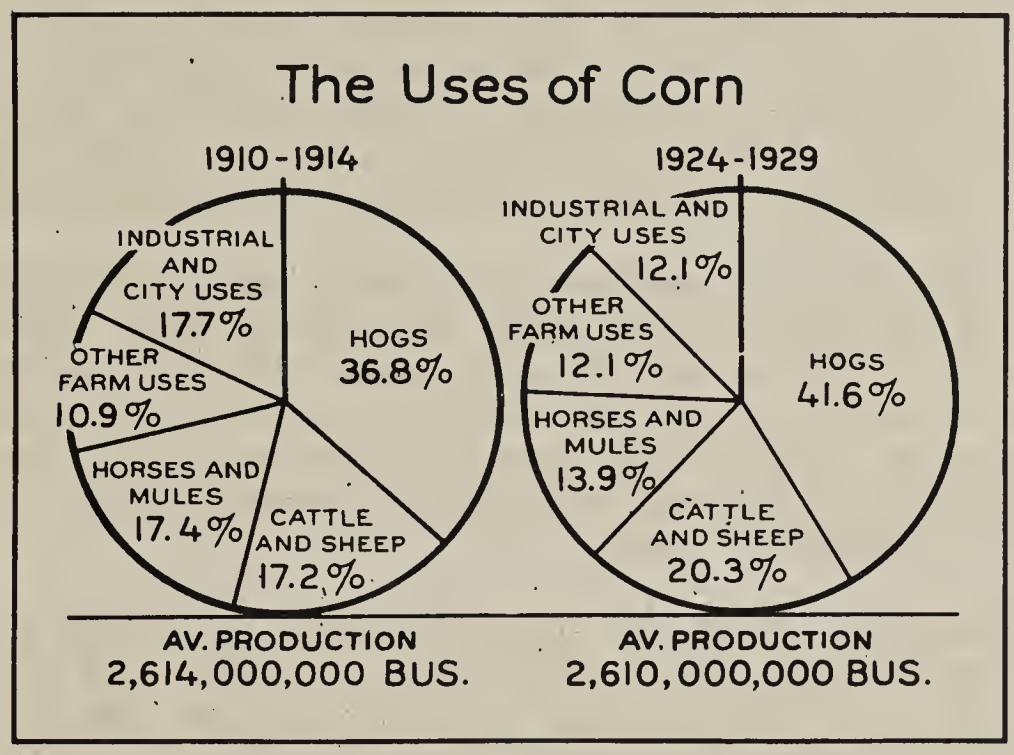
Corn: Utilization, 1910-1914 and 1924-1929

	1910-1914 inclusive	Percentage of crop	1924-1929 inclusive	Percentage of crop	Increase of decrease
	Million bushels		Million bushels		Percent
Horses and mules on farms	455	17.4	362	13.9	- 20.4
Cattle on farms	424	16.2	505	19.3	+ 19.1
Hogs on farms	963	36.8	1,085	41.6	+ 12.7
Sheep on farms	26	1.0	26	1.0	0.0
Poultry on farms	235	9.0	270	10.4	+ 14.9
Livestock not on farms	183	7.0	65	2.5	- 64.5
Industrial and commercial utilization	235	9.0	230	8.8	- 2.1
Exports	44	1.7	23	.8	- 47.7
Families on farms	31	1.2	26	1.0	- 16.1
Seed	18	.7	18	.7	0.0
Total	a/ 2,614	100.0	2,610	100.0	- 0.2

a/ Preliminary revision. Average of 1933 Yearbook of Agriculture figures, 1910-1914, is 2,732,000,000 bushels.

These figures and the following chart show that in recent years more than four fifths of America's corn crop of more than 2 1/2 billion bushels has been fed to livestock, and that nearly 42 percent of the entire crop has been fed to hogs alone.

This chart also shows a shift in the utilization of corn for various purposes from the 1910-14 period to the 1924-29 period. There has been an increase in the amount of corn used for the production of hogs, beef cattle, sheep, poultry, and for other farm uses. The proportion of corn used as feed for horses and mules had dropped off sharply on account of the decline in horse and mule numbers. Likewise, industrial and city uses also have dropped off due to some extent to the fact that trucks and tractors have replaced most of the horses formerly used in cities and towns.



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RESEARCHES IN THE UNITED STATES DEPARTMENT OF AGRICULTURE ON NEW USES FOR FARM PRODUCTS

U. S. Department of Agriculture Yearbook 1933. p. 40.

Calcium Gluconate - Lignin - Furfural

"Chemists in the Department developed a low-cost method of producing calcium gluconate by the action of a mold on corn sugar. Calcium gluconate is of great value in treating various diseases, and its production by the new method can utilize much surplus corn.

"Recent work on lignin, a component of all agricultural wastes, has shown that several synthetic resins can be produced from it, as can eugenol, the essential constituent of oil of cloves, and vanillin, the flavoring constituent of vanilla.

"By processes developed in this Department, industrial chemists produced from agricultural wastes last year more than 1,000,000 pounds of furfural. Some 5,000,000 pounds of oat hulls, which would otherwise have been wasted, were thus utilized."

NEW USES FOR FARM PRODUCTS

Browne, C. A. Chemical Utilization of Farm By-Products has Large Prospects. U. S. Dept. of Agriculture Yearbook 1932. pp. 513-517.

"A careful distinction must be drawn between agricultural-chemical products which are of primary origin and those of secondary origin. The products in the first group are produced directly by the plant or animal; cellulose, starch, sucrose, lactose, dextrose, citric acid, tartaric acid, fat, and protein are examples of this very large primary group. The products of secondary origin are obtained from the primary group by some process of chemical modification such as fermentation, dehydration, hydrolysis, oxidation, reduction, or destructive distillation. Alcohol, acetic acid, lactic acid, furfural, glycerol, dextrine, and methanol are examples of familiar chemicals belonging to this secondary group. ...

"In the case of residues the farmer must carefully determine whether they are not of more value to himself when converted into cattle feeds, fertilizers, or humus than when sold as raw materials for the manufacture of xylose, furfural, methanol, acetic acid, or other chemicals. Using them upon the farm as cattle feed or compost may in the end be more remunerative than selling to industry for a small pittance of cash.

"Methods of using the cereal straws, the world's most abundant agricultural by-product, have attracted the most attention from chemists. In Europe straw is utilized upon the farm for composting, for thatching haystacks, barns, and other buildings, and also as a cattle feed, for which purpose it has been subjected to various chemical treatments for increasing its digestibility. Straw is also used in Europe for manufacturing low-grade papers and is compressed into panels which are sold under the name of 'thatchboard' for constructing the walls and partitions of buildings. Straw and cornstalks are also converted into building and insulating boards in the United States, but as raw material for this purpose they must compete with the waste of lumber mills. The destructive distillation of straw and cornstalks in producing carbon, illuminating gas, methanol, acetic acid, and other substances has also been done in the United States but not with complete economic success, since these products can be made more cheaply from other sources.

"The most perfect chemical means for working up straw, stalks, hulls, and other cellular residues is the one that utilizes most completely each one of their three major components - cellulose, pentosans, and lignin. ...

"Of these three ingredients the market for cellulose as a raw material for the manufacture of paper, rayon, nitrocellulose, and other industrial products, is at present the most extensive. The market for pentosans as a raw material for the manufacture of adhesives, xylose, and furfural is very restricted. Sufficient xylose can be made from a few tons of corncobs or oat hulls to satisfy the present demands of the world for many years. One of the greatest services which the chemist can render agriculture is the discovery of new industrial uses for xylose and furfural, millions of tons of which can be manufactured each year from the pentosans in the residues of our cereal and other crops....

"Lignin, the third major constituent of the straw, stalks, hulls, and other cellular wastes of agriculture, has at present a very limited market as a raw material for industrial utilization. The ultimate possibilities in this direction seem, however, to be very great, and with reference to the utilization of lignin, synthetic chemistry stands to-day in about the same position as it stood over a century ago with reference to the utilization of coal tar in which such brilliant industrial achievements were later attained. ...

"Future developments in the chemical utilization of the surpluses and wastes of agriculture are dependent (1) upon creating new uses for the immense quantities of cellulose, starch, sucrose, lactose, xylose, furfural, acetic acid, oxalic acid, methanol, alcohol, and other substances which can be obtained by known methods from our present reserves; (2) upon discovering new methods for converting lignin and other undeveloped plant constituents into useful chemical derivatives. The synthetic chemist should be viewed by the agriculturist not as an enemy who is to accomplish 'the complete demolition of crop cultivation' but rather as a valuable collaboratory who will help the farmer to derive greater profits from the residues which at present are wasted or only imperfectly utilized."

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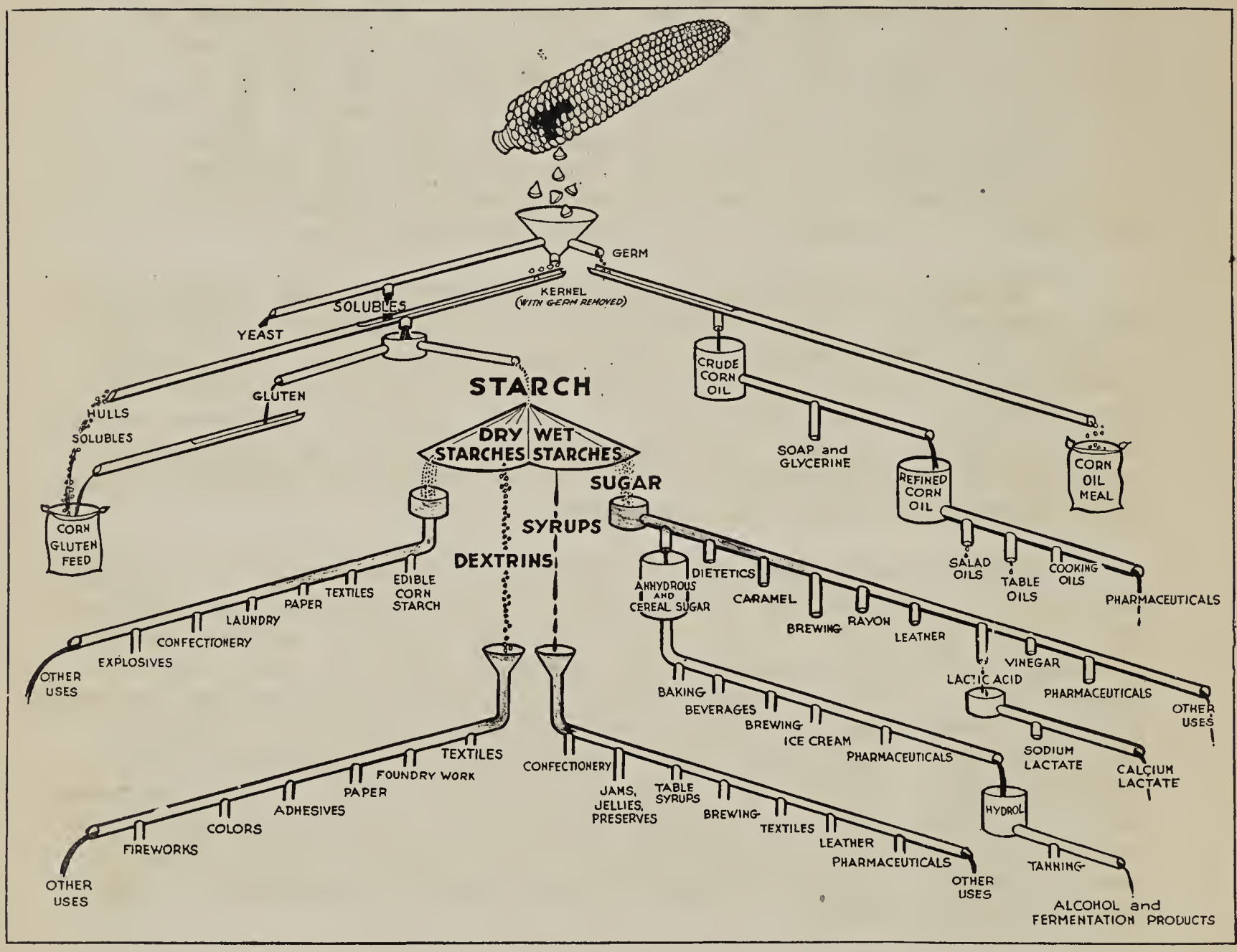
CORN'S CORN TO A HOG - BUT LOOK WHAT IT IS TO A CHEMIST!



When nature leaves off, science begins, and the lowly kernel of corn becomes a mine of varied riches. From ordinary field corn, after trial and error in years of research, the chemists of the corn refining industry are taking scores of useful products that many other industries are glad to have. The growing demand for these processed products now uses about one-third of all the corn that moves through the principal markets. The promise of further growth and development is one of the most hopeful phases of the agricultural outlook and may, in the early future, go far towards answering the ever-present problem of corn surplus.

CORN INDUSTRIES RESEARCH FOUNDATION

HARVESTING CORNSTALKS FOR INDUSTRIAL USES

Davidson, J. B. and Collins, E. V. Iowa State College. Agr. Exp. Sta. Bull. 274. pp. 374-394. 1930.

Following is a summary of the study made by the Iowa State College:

"The development of industrial uses for cornstalks is dependent, in a large measure, upon an adequate supply of raw material at a reasonable cost.

"Cornstalks, being light and bulky, are difficult to handle, and economical harvesting is essentially a problem of reducing labor.

"The yield of cornstalks (15 percent water content basis) varies from 1 to 2 tons per acre.

"Dry, wind-blown stalks in Iowa may be expected to yield from 1/2 to 1-1/2 tons per acre.

"Cornstalks cannot be harvested economically by hand.

"Harvesting with corn binder, husker-shredder and baler costs about $7 per ton under average conditions.

"Harvesting by breaking, raking and baling in the field is a very practicable method, and the cost for average conditions is about $3.55 per ton. Under favorable conditions the cost may be $2.70 or less per ton.

"Combination machines, consisting of mower, rake and baler, reduce labor. The harvesting of 236.8 tons at Ames, Iowa, in 1930 cost $2.49 per ton, exclusive of machinery costs. A reasonable estimate of the cost of machinery, exclusive of power, is 50 cents per ton.

"New machines are being developed. A combination corn picker and field baler is such a machine.

"The cost of collecting baled stalks in the field, transporting 8 miles and unloading, is about $1.80 per ton. Collecting of 236.8 tons of stalks at Ames, Iowa, hauling to station 1 to 4 miles and loading into cars, cost $1.23 per ton.

"Special freight rates are in force for shipping baled cornstalks. ...

"In the purchase of cornstalks, deduction must be made for excess dirt and water.

"Cornstalks when baled without shredding do not absorb water so readily and tend to store better when piled. The capacity of the baler, however, is increased if the stalks are shredded and the weight of bales is increased.

"The cost of piling cornstalks was 35 cents per ton with an inclined elevator."

CORNSTALKS AS AN INDUSTRIAL RAW MATERIAL

Sweeney, O. R. and Arnold, L. K. Iowa State College. Eng. Exp. Sta. Bull. 98. 48 pp. Ames. 1930.

This bulletin summarizes studies which have been made relating to the composition, yield, cost of harvesting, time to harvest, transportation and storage of cornstalks, and discusses the value of stalks for agricultural purposes.

The exact value of cornstalks as a food for domestic animals the authors say cannot be stated. Literature on this subject is reviewed and the following conclusion drawn: "It is evident that corn stover has very little if any food value for dairy cows."

As a fertilizer the following conclusion is drawn from the experimental studies made: "It is evidently not possible to assign to cornstalks a definite value as a fertilizer. Their value depends upon many things, as type of soil, climate, and crops to be raised. On a soil needing humus they might be of considerable value for that purpose. On some soils they have a slight fertilizer value while on other soils they will have a detrimental effect. On soil receiving no more than the necessary moisture the stalks will be detrimental. There is no evidence available that on Corn Belt soils the addition of cornstalks is beneficial, there is reason to believe that it may do harm."

As a means of combating the corn borer the authors say: "The industrial utilization of the stalks can be made a very effective means of combating the corn borer."

CORNSTALKS FOR PAPERMAKING

Weber, C. G., Shaw, M. B., and O'Leary, M. J. Paper Making Quality of Corn Stalks. U. S. Nat. Bur. Standards. Misc. Pub. M 147, 9 pp. 1935.

The National Bureau of Standards made a study of the paper making quality of cornstalks "to find the practical possibilities of utilizing this form of waste farm products as a raw material for paper. Special mechanical preparation of the stalks was found essential for successful pulping because of certain structural peculiarities of the type of plant stem. The best results were obtained by using only the outside shell or cortex, which had been separated from the remainder and shredded by mechanical processes."

The following are the conclusions arrived at by the investigators:

"The low strength of cornstalk fibers, together with the comparatively high raw-material and manufacturing costs, appears to preclude at present commercial success in utilizing domestic cornstalks for ordinary wrapping papers and similar unbleached papers.

"White pulp of satisfactory quality for medium grades of writing papers, and bleached wrapping specialities such as butter and lard wrappers was produced. However, the commercial manufacture of this type of pulp does not appear feasible at the present time on account of the relatively high costs of raw materials and conversion. Before the process can be of commercial interest under present conditions, it will be necessary to find profitable uses for the pith and fine fibrous material which are left after separating the cortex. If these or other byproducts 1/ could be made to pay the cost of separating the cortex and one-half the raw material costs, reducing the cost of the cortex to about $18 per ton of pulp, it is possible that the cortex could be used profitably for bleached pulp."

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1/ Materials obtained experimentally from cornstalks that may ultimately be of commercial interest include xyclose, alcohols, adhesives, lignin, maizolith, furfural, plastics, and low-density thermal and sound-insulating material from the pith and fines.

SEPARATION OF CORNSTALKS

Whittemore, E. R., Overman, C. B., and Wingfield, Baker. Separation of Cornstalks into Long Fibers, Pith, and Fines. U. S. Nat. Bur. Standards. Misc. Pub. M148. 8 pp. 1935.

Method of Separating Pith from Cornstalks

"The wet method of separating pith from cornstalks was modified to produce three fractions of useful materials.

"The method consisted in a preliminary coarse shredding, preferably in a wet condition to minimize the production of fine material, washing the shredded material with water to remove most of the loose dirt, breaking the pith free from the shell and inner fibers by a wet mechanical treatment, separating the pith, 'fines', and dirt from the long fibers by wet screening, and separating the pith from the fines and dirt by water flotation. ...

"The yields are 42.5 percent of long fiber, 5 percent of pith, and 22.5 percent of fines.

Cost and Uses

The cost and yield figures are given in the following table. The power costs are based on power consumed by the small equipment used in the experimental work. The water costs are based on pumping and filtering the volume of water used since fresh water would be expensive at ordinary prices.

Cost data

		Long fiber	Pith	Fines
Tons	1.00	0.425	0.05	0.225
Power at 1 cent a kilowatt hour		$0.75	$0.09	$0.40
Water at 0.8 cents a 1,000 gallons		.38	.05	.20
Fuel for drying			.15	.69
Total		1.18	.29	1.29
Cost a ton	$2.76	2.65	5.90	5.73

"To these costs would have to be added those for labor, raw material, overhead, etc. The values given in the table have been apportioned between the three products according to the weight of each.

"The three components of cornstalks have many possibilities for utilization in industry. The chemical analysis of each fraction is very nearly the same, but the differences in physical characteristics give them a wide range of usefulness. The long fiber, after suitable treatment, has the possibility of economical use in making paper, insulation board, and pressboard. The pith has interesting possibilities as an insulating material. Tests by the heat and power division of the National Bureau of Standards indicate that its thermal conductivity is as low as that of cork, while its density is much less. In a wet condition the pith can be beaten, molded into boards or blocks and dried. These boards have approximately the same thermal conductivity as the original material, but with a greater density. In the granular and molded forms pith can be used as insulation material in refrigerators, refrigeration cars, house insulation, and because of its low density it might find application in airplane insulation. Further, it might find an outlet as a substitute for ground cork in the manufacture of linoleum. Pith is easily nitrated and it is possible that it might be valuable as a raw material for the manufacture of explosives.

"The fines should find outlets as material for pressboard, insulating material, and possibly as a substitute for wood flour in the manufacture of linoleum."

PRODUCTION OF INSULATING BOARD FROM CORNSTALKS

Sweeney, C. R. and others. Iowa State College. Eng. Exp. Sta. Bull. 102. 64 pp. 1931.

Experimental studies made by the Iowa Engineering Experiment Station showed that "good insulating board can be made from cornstalks by various processes. Semi-commercial studies showed that excellent insulating board can be made from pulp produced by digesting cornstalks in water and from pulp produced by mechanically pulping cornstalks. Various combinations of refining equipment were compared and it was shown that excellent results could be secured by using a rod mill and a Claflin refiner in series. A new forming machine was designed and perfected. Sixing, fireproofing, and waterproofing were studied. Methods and apparatus for testing the pulp and finished board were developed" and reported in the bulletin.

The authors report that other raw materials may be used in insulating board manufacture and include wood waste, extracted beet pulp, seaweed, swamp grass, banana stalks, wheat straw, oat straw, seed flax straw, cotton stalks, oat hulls, cotton seed hulls, broom corn stalks, corncobs, cornstalks, and several other fibrous materials. But cornstalks have the advantage over other raw materials in the middle west.

"Satisfactory boards, resembling very closely those from field corn, were made from sweet corn, pop corn, and broom corn stalks."

"Rigid insulating board is extensively used in place of lath and plaster. Among its advantages for this purpose are: greater heat insulating properties, greater ease of application, no time lost waiting for plaster to dry, and it may be adapted to panelling construction. It may be applied with wooden strips covering the joints so as to produce a panel effect or the joints may be filled and the wall papered. Very pleasing effects result with either the decorated or undecorated board.

"Insulating board may be used instead of lath as a plaster base. When used in this manner it has the advantage over lath of possessing greater insulating value, requiring less labor in applying, and having greater structural strength.

"The insulating type of board is being used extensively in place of wooden sheating under stone or brick veneer. For this purpose it has the advantage of greater ease of application, greater structural strength, and greater heat insulating properties than the usual wooden sheathing. It is also used extensively under the roofs of factory buildings to prevent condensation of water on the underside. It is an efficient insulator for refrigerators, refrigerator cars, and cold storage rooms. It is used on the outside of summer cottages and temporary buildings. If kept well painted it will give splendid service. Even when not painted or waterproofed these boards weather remarkably well."

USE OF ALCOHOL FROM CORN IN MOTOR FUEL

Use of Alcohol From Farm Products in Motor Fuel. A Report Submitted by the Secretary of Agriculture. Prepared in the Bureaus of Agricultural Economics, Chemistry and Soils, and Agricultural Engineering. U. S. Department of Agriculture. Senate Document 57, 73rd Congress, 1st Session. 55pp. May 1933.

Behavior of Alcohol-Gasoline as Motor Fuel

p. 7. The results of many observations and experiments in the use of alcohol-gasoline mixture in this country and abroad as motor fuel may be summarized as follows:

1. Mixing of alcohol with gasoline makes for smoother engine operation.

2. The adding of small proportions of alcohol to gasoline improved combustion and tends to prevent carbon formation.

3. The corrosive effects of small proportions of alcohol in mixtures with gasoline appear to be negligible.

4. There appears to be a tendency toward harder starting when using blends, particularly in cold weather and as the percent of alcohol is increased.

5. Existing engines appear to be able to handle up to 10 percent absolute alcohol-gasoline blends with but little adjusting of the carburetor or point of ignition.

6. The solvent effect of alcohol may cause trouble with cork-floats in carburetors and fuel tanks. The loosening of scale and gum deposits in fuel systems may cause some difficulty; but this may become negligible after the fuel tank is exhausted the first few times (the action may cause some trouble with diaphrams in automobile fuel pumps). It is also detrimental to automobile body finishes.

7. Alcohol improves the octane rating at the rate of from three fourths to one number for each percent of alcohol added. (By adding 10 percent alcohol to three regular gasolines the average rating was increased from 66 to 74 and increases the rating of low grade more than the regular gasoline.)

8. As the percent of alcohol in the blend is increased the compression could be increased without detonation up to roughly 200 pounds on pure alcohol. At the optimum compression, fuel consumption of the blend would approach that of gasoline. But a pressure of 200 pounds per square inch would make starting difficult and necessitate change in ignition systems.

9. Equal power and acceleration of alcohol-gasoline blends and gasoline appear possible in the same engine but at a higher fuel consumption with the blend as the alcohol percentage increases. Roughly speaking, the consumption of alcohol alone would be 50 percent greater than with

gasoline alone. As the percent of alcohol in the blend is decreased the consumption approaches gasoline.

Yield of Alcohol from Different Agricultural Products

p. 13: "The yield of alcohol from the different agricultural products varies, of course, with the character of the materials involved and the efficiency of the distillery operations. The malting of the starchy materials and the fermentation of sugars with yeast require much technical skill and the observance of many precautions to obtain the highest yields of alcohol. In table 1 there are indicated the approximate yields of both 95 percent and absolute (99.5 percent) alcohol from various sources which are obtainable under proper conditions. There is also indicated in this table the quantity of malt required (based upon a mixture by weight of 88 percent grain and 12 percent malt) for starch conversion, and the percentage by weight of the dried distillers' grains which may be recovered and sold as a stock feed. These yields of alcohol and distillers' grains have been used in estimating the cost of alcohol production.

Table 1. Farm crops available as sources of alcohol - Tabulation of potential yields

Kind of material	Weight per bushel	Approximate yield gallons of 95 percent alcohol per bushel	Approximate yield gallons of 99.5 percent alcohol per bushel	Bushels of malt required per bushel of base material	Approximate yield of distillers' grains in percent of total material weight
Corn	56	2.5	2.36	0.225	22.3
Wheat	60	2.8	2.64	.241	26.9
Sorghum	50	2.1	1.98	.201	24.4
Rye	56	2.3	2.17	.225	27.1
Rice (rough)..	45	1.9	1.79	.181	26.0
Oats	32	1.1	1.04	.120	42.3
Potatoes	60	.8	.76	.073	3.8
Sweetpotatoes.	55	1.0	.94	.085	4.0

Cost of Alcohol-Gasoline Blend

p. 20. "The effect of blends upon the cost of a gallon of motor fuel is indicated as follows:

Cost of alcohol-gasoline blend, using gas at 13 cents per gallon

	Cost of corn alcohol per gallon		
	27.2 cents	39.3 cents	51.5 cents
	Cents	Cents	Cents
2 percent	13.28	13.53	13.77
5 percent	13.71	14.32	14.93
10 percent	14.42	15.63	16.85
	addition to price of gas on account of alcohol blend		
	Cents	Cents	Cents
2 percent	0.28	0.53	0.77
5 percent	.71	1.33	1.93
10 percent	1.42	2.63	3.85

Supplies of Raw Materials for Alcohol

p. 21. "Anhydrous alcohol, for a 2 percent blend with 15,000,000,000 gallons of motor fuel, would require equivalents of about 112,000,000 bushels of corn, and 23,000,000 bushels of barley. A 5 percent blend would require about 280,000,000 bushels of corn and 57,000,000 bushels of barley; and a 10 percent blend, 560,000,000 bushels of corn and 114,000,000 bushels of barley."

Manufacturing and Operating Costs

p. 1. "Using large economically operated units, the cost of anhydrous alcohol made from 25-cent corn would be about 27 cents; from 50-cent corn, about 39 cents; and from 75-cent corn, about 52 cents per gallon. The manufacturing cost from corn by ordinary processes would vary from about 7 to 11 cents per gallon, depending upon the size of the plant. Denaturing and distributing, together with some allowance for profit, would add about 9 cents per gallon to the manufacturing costs.

"Blending alcohol with gasoline at present prices would increase the cost of a gallon of motor fuel. With corn at 50 cents per bushel and gasoline at 13 cents per gallon, the use of 2 percent anhydrous alcohol would add about one half cent; and the use of 10 percent would add about 2 3/5 cents per gallon to the cost of motor fuel. This would, of course, increase the cost of motor power to farmers as well as to the public generally, but not without offsetting benefits."

p. 13. "The cost of producing alcohol obviously depends upon a number of factors, such as the location of the distillery, the kind of materials used, the price paid for the raw materials, the efficiency of the manufacturing plant due to management and the scale of production. There are no published data regarding the cost of producing absolute alcohol from grains under present conditions but estimates which have recently been made have been submitted to the Department of Agriculture."

p. 18. ..."The average cost of alcohol to the consumer at different prices for corn would be about as follows:

Corn	Cost of alcohol
Cents per bushel	Cents per gallon
25	27.2
50	39.3
75	51.5

p. 14. Complete cost for producing 99.5 percent alcohol from corn, at different prices for corn and malt

	112 tons mixed grains, 88 percent corn, 12 percent malt			700 tons mixed grains, 88 percent corn, 12 percent malt		
Gallons of alcohol produced per day	9,440	9,440	9,440	59,000	59,000	59,000
Cost of corn at distillery (cents per bushel)	25	50	75	25	50	75
Cost of malt at distillery (cents per bushel)	50	100	150	50	100	150
Bushels of corn used per day	3,520	3,520	3,520	22,000	22,000	22,000
Bushels of malt used per day	790	790	790	4,940	4,940	4,940
Feed (distillers' grain) produced (tons per day)	25	25	25	156	156	156
Value of feed (dollars per ton)	10	15	20	10	15	20
Cost of corn (dollars per day)	880	1,760	2,640	5,500	11,000	16,500
Cost of malt (dollars per day)	395	790	1,185	2,470	4,940	7,410
Total	1,275	2,550	3,825	7,970	15,940	23,910
Credit for feed (dollars per day)	250	375	500	1,560	2,340	3,120
Net cost of raw materials (dollars per day)	1,025	2,175	3,325	6,410	13,600	20,790
Net cost of raw materials (cents per gallon of alcohol)	10.9	23.0	35.2	10.9	23.0	35.2
Processing and distributing costs (cents per gallon of alcohol)	20.5	20.5	20.5	16.3	16.3	16.3
Total cost of 99.5 percent alcohol at point of blending with gasoline (cents per gallon)	31.4	43.5	55.7	27.2	39.3	51.5

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USE OF CORN ALCOHOL AS A MOTOR FUEL

Observations made by the U. S. Bureau of Chemistry. Reported by H. G. Knight, Chief. Oil, Paint and Drug Reporter 123: 40. April 3, 1933.

"(1) The operating cost of the production of alcohol is quite definitely known. In large production, alcohol can be produced from molasses (the cheapest raw material now available) at an operating cost of about 6 cents and from corn at about 7 cents per gallon of alcohol. To this amount is added the price of the raw material to obtain the net cost. With molasses at 5 cents per gallon (2 1/2 gallons molasses yield one gallon alcohol), this would mean that the alcohol would cost 18 1/2 cents, but this does not include the distribution, denaturing charges, and profit. The cost of producing a gallon of alcohol from corn (a bushel of corn will yield 2 1/2 gallons of alcohol) is greater than producing it from molasses, since the 'mashing' and fermenting of the corn is a more costly operation than merely diluting and fermenting molasses. We have been advised recently by representatives of the industrial alcohol industry that a fair charge to cover distribution, denaturing, and profit would be from 8 to 10 cents per gallon, to which should be added 1/2 to 2 cents for dehydrating in order to obtain the 99.6 percent alcohol which is necessary if it is to be used as motor fuel. These charges will vary of course with the individual plant, depending upon availability of raw materials and efficiency of operation. This means that dehydrated alcohol can probably be produced, if there is sufficient demand for it, at a cost of between 30 and 35 cents per gallon. ...

"(2) Commercial alcohol contains varying amounts of water, and should be dehydrated before mixing with gasoline, otherwise the mixture of alcohol, water and gasoline tends to separate into two layers, depending upon the content of water and the temperature. Anhydrous alcohol is quoted today in tankcar lots at 50 cents per gallon. It is believed that it cannot be produced for much under 40 cents per gallon even in larger quantity production.

"(3) In foreign countries where the mixtures have been advocated and used several reasons have prevailed:- (a) Gasoline is an imported article of high cost. (b) In some cases alcohol production is a state monopoly. Its forced use with a tax is a method of raising revenue. (c) In tropical or subtropical countries where engine starting difficulties are perhaps of less importance than in colder climates, alcohol-gasoline mixtures may be used with some degree of success. For the above reasons the mistake should not be made of attempting to apply deductions from foreign experience under quite different circumstances to conditions which prevail in this country.

"(4) The method of dispensing fuel mixtures is an important one and needs very serious consideration. Distributing such mixtures through service station pumps where the absorption of moisture from the atmosphere

by the alcohol-gasoline mixture probably would be at its maximum, is perhaps quite a serious matter and may involve a serious distribution difficulty.

"(5) The proper denaturing of alcohol-gasoline, mixtures under present conditions at least is a matter of grave concern. The type of denaturing agent must be considered as a factor in motor operation.

"(6) The incomplete combustion of alcohols in the engine cylinders may lead to difficulties. The chemistry of such decomposition, including the added denaturant, is quite involved, but acids, aldehydes, etc., may be produced. It is generally recognized that a possible effect of the use of alcohol will be an increased corrosive effect upon engine parts, but just how important this effect will be had not yet been determined.

"(7) Preliminary investigational work by the Bureau of Agricultural Engineering has developed that the antiknock characteristic of ordinary gasoline can be definitely improved by the addition of absolute alcohol. In the light of present trends of engine design, this is a desirable characteristic.

"(8) Incomplete tests of the effect of alcohol admixtures on economy and the maximum obtainable horsepower are not conclusive. When used in tractors and trucks such as are in common use on farms, the alcohol admixtures in some tests showed a slight increase while others showed a small decrease in these two factors of operation. However, the difference in performance resulting from the addition of alcohol was not great in either direction.

"(9) Attention should be called to the fact that absolute alcohol and gasoline will not remain entirely in solution if water is introduced into the admixture. Since alcohol is hygroscopic there will necessarily be some moisture absorbed even under the best conditions. The addition of certain compounds, such as benezene, acetone, or butyl alcohol, tends to offset the effects of moisture, thereby keeping the elements in solution, but the use of these will undoubtedly increase the cost of the fuel. A great deal of trouble has been had heretofore in the proper use of the alcohol mixture on account of the tendency of the admixture to separate into its component parts."

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AMOUNT OF CORN USED IN THE WET-PROCESS INDUSTRY

U. S. Department of Agriculture Yearbook 1935. p. 388.

Corn: Wet-process grindings
November 1928 to October 1934, Incl.

Year beginning November	1,000 bushels
1928-29	88,198
1929-30	77,490
1930-31	66,554
1931-32	62,002
1932-33	71,829
1933-34	69,899

Bureau of Agricultural Economics;
Compiled from reports of the Corn Refiners' Statistical Bureau and the Corn Industries Research Foundation.

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SALES OF CERTAIN PRODUCTS OF THE WET-PROCESS INDUSTRY

U. S. Department of Agriculture Yearbook 1935. p. 390.

Corn: Sales of Certain Products of the Wet-process Industry,
1928-1934

Calendar year	Corn starch	Corn sugar	Corn sirup mixed and unmixed	Dextrines	Corn oil		Feed	
					Crude	Refined	Gluten feed and meal	Corn-oil meal
	1,000 pounds	1,000 pounds	1,000 pounds	1,000 pounds	1,000 pounds	1,000 pounds	1,000 short tons	1,000 short tons
1928	838,605	968,601	1,106,957	110,169	43,507	74,153	659	40
1929	879,560	894,986	1,111,153	114,486	53,661	78,913	634	27
1930	710,525	849,315	1,025,970	89,720	40,004	77,924	576	25
1931	635,974	802,052	929,342	79,136	41,076	71,537	479	21
1932	529,329	776,854	794,926	62,122	35,127	76,437	542	18
1933	741,854	836,650	1,000,941	86,222	37,246	81,153	508	23
1934	666,869	633,233	996,172	69,947	42,400	87,109	599	21

Bureau of Agricultural Economics;
Compiled from reports of the Corn Refiners' Statistical Bureau.

CORN STARCH

Foodstuffs Division, U. S. Bureau of Foreign and Domestic Commerce. 1933. [Mimeographed.]

"Corn starch is manufactured from the raw starch of corn by breaking it up, washing and siphoning repeatedly, running over sieves of fine silk which remove any particles of fiber still adhering, putting through various other refining processes until the water content has been reduced to only about 10 percent, and finally pulverizing.

"The trade names for the two recognized and prominent corn starches are pearl starch and powdered starch. They are the same in quality, but a differential of about 10 cents per hundred pounds is generally charged for the powdered over the pearl. Corn starch enters into many industries, as is shown further on.

"The corn starch industry is one of the industries that has developed very rapidly in recent years in the United States, and plays an important part in both our domestic and foreign trade. ...

"The production of corn starch in the United States from 1904 to 1931, inclusive, in million pounds was as follows:

1904	311.1	1923	839.4
1909	639.0	1925	854.1
1914	547.2	1927	933.2
1919	728.0	1929	1,046.2
1921	860.2	1931 1/	742.3

1/ Preliminary

These figures include only commercial corn starch sold as such either in bulk or in packages, and do not take into consideration starch that is converted into glucose (corn syrup.) Of the amount produced in 1929, 235,042,000 pounds were exported.

"Exports for 1930 declined to 153,702,000 pounds, 1931 to 87,719,000 pounds, and 1932, 52,052,000 pounds. ...

"The corn products industry of the United States ground 86,620,041 bushels of corn in 1929, 75,662,083 buehsle in 1930, 66,857,478 bushels in 1931 and 61,579,858 bushels in 1932. This is between 15 and 20 percent of all of the so-called cash corn, that is, corn that comes into the market.

"The great bulk of our corn crop, averaging about 2,850,000,000 bushels annually never leaves the farm, being fed to hogs and other livestock on the farm where it is grown, only about 450,000,000 bushels

annually entering commercial channels. In the year 1931 the industry produced 980,236,890 pounds of corn syrup valued at $25,762,830, 802,440,322 pounds of corn sugar valued at $20,441,278, and $135,658,517 pounds of corn oil valued at $11,810,901. The toal value of all products was $85,857,837, compared with $133,573,267 for 1929, the peak year.

"The United States has a practical monopoly of the corn starch industry, being the only country that produces this commodity in appreciable quantities, although, some production is being developed abroad by American branch factories. ...

Uses of Corn Starch

"Commercial corn starch goes into many different industries, and finds many uses - the amount sold by grocers for food and home laundry purposes being the largest use, and the textile industry second.

"The following table, taken from the annual reports of the Corn Industries Research Foundation, shows details of the distribution among the various trades of the 1929, 1930, 1931, 1932 and 1933 outputs."

Sales Distribution Report
Of The Corn Industries Research Foundation

For Entire Industry - for Years 1929 to 1933, inclusive.

CORN STARCH - distribution among different trades as below (in pounds*)

	1929 1,000 lbs.	1930 1,000 lbs.	1931 1,000 lbs.	1932 1,000 lbs.	1933 ** 1,000 lbs.
Bakers, Bakers' Supply, Flour Millers and Mixers	30,827	27,821	25,819	19,548	22,206
Baking Powder Manufacturers	49,719	43,734	53,513	52,898	62,613
Brewers (refined grits)	1,282	459	243	581	17,722
Confectioners and Confectioners Supply	32,799	31,694	28,826	22,316	29,701
Chemists, Color Manufacturers and Explosives	27,191	19,780	15,872	15,130	23,095
(1) Dealers and Repackers (bulk)	36,206	41,740	50,645(	(40,676	61,704
Dextrine Makers and Founders	43,763	10,767	9,925(		
Paper, Paper Box, Paste, Bill-board and Asbestos	76,249	67,657	58,246	54,070	81,317
(2) Grocers (Packages)	146,407	135,581	128,461	124,182	169,475
Laundry (Bulk to Laundry Trade)	15,097	15,238	16,377	14,371	15,704
Cotton Mills and Other Textiles	144,925	117,686	119,568	103,011	150,485
(3) Miscellaneous	53,870	48,792	46,743	34,874	47,671
Export	221,226	149,576	81,735	48,528	60,163
Total	879,560	710,525	635,974	530,185	741,855

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*A bushel of corn produces from 30 to 34 pounds of starch
**1933 data furnished by U.S. Bureau of Foreign and Domestic Commerce, 1934.

"Note: The export figures shown here do not agree with the official figures, because this table is taken from unofficial sources, and no doubt includes shipments that had been made from various factories, but had not been cleared through custom houses.

(1) Approximately 35 percent for mechanical use, 45 percent for laundry starch and 20 percent for food purposes.

(2) Around 30 percent for food and 70 percent for laundry purposes.

(3) Practically all for mechanical purposes.

These figures represent only actual sales during the year and do not take into consideration stocks on hand."

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CORN RECEIPTS AT TERMINAL MARKETS

U. S. Department of Agriculture Yearbook 1935. p. 385

Corn, shelled: Classification of receipts graded by licensed inspectors, all inspection points, total of all classes under each grade, 1928-29 to 1933-34

Year beginning November	Grade							Total
	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	Sample	
	Cars	Cars	Cars	Cars	Cars	Cars	Cars	Cars
1928-29	25,809	92,285	73,331	93,367	40,594	10,400	7,247	343,033
1929-30	26,394	85,038	49,806	50,916	39,995	19,475	16,580	288,204
1930-31	18,176	67,781	70,928	45,629	14,745	5,262	3,745	226,266
1931-32	15,469	91,136	53,076	22,756	3,987	3,159	2,465	192,048
1932-33	12,217	129,825	63,005	29,343	6,487	7,218	6,632	254,727
1933-34	39,099	117,613	47,066	14,113	3,953	2,592	3,064	227,500

Bureau of Agricultural Economics.

PUBLICATIONS RELATING TO USES AND PRODUCTS MADE FROM CORN*

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Describes fermentation process of producing acetic acid from cellulose wastes, including corncobs, which is covered by a British patent, No. 248,795 of Herbert Langwell.

Alcohol in motor fuel. Oil, Paint and Drug Reporter 123: 14, 40, 57. April 24, 1933.
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Synthetic cornstalk lumber an economic myth. Jour. Forestry 31: 100-1 January 1933.

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