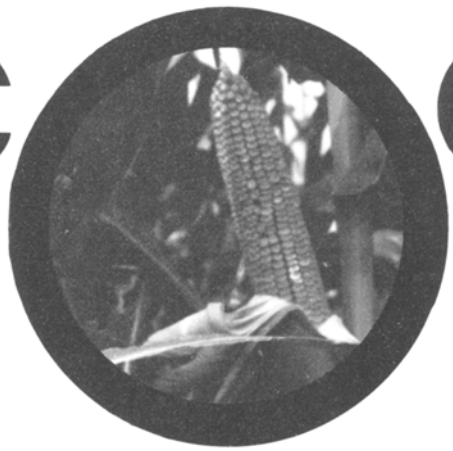
**Feature**

# Corn Oil



*Although not a major oil in terms of quantity handled on the world market, corn oil is perhaps one of the best known to U.S. consumers. JAOCS news staffer Barbara Fitch Haumann has prepared the following report on corn oil production and use in the U.S.*

## Production up as corn refining grows

Corn oil, considered a premium oil domestically and abroad, historically has been a minor commodity on the world market because of limited supply. Now, however, the industry is experiencing substantial growth, due chiefly to increased demand and production of high fructose corn syrup made from corn starch.

Because corn oil is a by-product of the corn starch and meal industries, its production is dependent strictly on demand for the major corn products of sweeteners, alcohol, starch and meal. "For many years, corn oil supplies were very limited. If the wet milling industry didn't grow, corn oil production wasn't going to either," Corn Refiners Association spokesman Kyd Brenner said. Growing use of high fructose corn syrup during the 1970s and early 1980s, as well as expanded use of fuel alcohol from corn starch, changed the picture. In 1984, both Pepsico Inc. and Coca-Cola Co. agreed to sweeten soft drinks with up to 100% corn sweetener, clinching acceptance of high fructose corn syrup. The resulting demand for high fructose corn syrup meant increased corn oil supplies.

According to Brenner, not only is corn oil production growing, but so is the amount being exported.

"There has been no difficulty finding markets for the larger amounts of corn oil. There had been a very large pent-up demand for corn oil, especially on the export market, which just could not be satisfied before. People were out there clamoring for it," Brenner said.

### Popular Image

"Corn oil always has had a good quality reputation abroad and here," Brenner said, citing purity, polyunsaturate composition and cooking properties for its acceptance. Also, he said, in some parts of the world such as the Middle East, there is a preference for corn oil, or corn oil blended with other vegetable oils.

In the U.S., consumers have been aware of corn oil longer than soybean oil, for instance. A consumer attitude and knowledge study conducted for the American Soybean Association in 1978 showed that consumers mentioned corn oil first when asked about vegetable oils, and ranked it above soybean and sunflowerseed oils. "It seems that most corn oil purchasers are aware of what they are buying; most soy purchasers are not, and health reasons are very important in making an oil purchase decision," the study report stated.

Corn oil's positive image in the U.S. can be partially credited to effective nutrition and health marketing of Mazola corn oil, perhaps the best known salad oil (see accompanying story). Even today, certain margarine manufacturers capitalize on that good image by advertising that their products are made with 100% corn oil.

"The marketing aim has been to maintain a separate image for corn oil," Brenner said.

According to consultant Robert A. Reiners, who worked for CPC International until he retired, corn oil was in the right place at the right time. "At the time research was being done showing a positive link between polyunsaturated fatty acids and lowering blood cholesterol, corn oil was readily available and had the highest concentration of polyunsaturated fatty acids," Reiners said, explaining that sunflowerseed and safflower oils, which have higher polyunsaturated content, were not as available. "Soybean oil was readily available at the time, but there was considerable doubt over its stability and problems with its flavor."

Reiners added, "CPC recognized very early that this link was potentially very important, and so it made corn oil available to researchers at no charge." The result was widespread use of corn oil in animal and clinical studies.

### Physical Properties

Corn oil is highly digestible and a good source of essential fatty acids. It has a light delicate flavor and is golden in color.

Typical triglyceride content of the crude oil is about 95%. Corn oil in the U.S. is high in linoleic acid, typically about 59%, and low in linolenic acid (less than 1.5%). It also has a high concentration of tocopherols and ubiquinone. Consequently, it

has good oxidative stability. Crude corn oil, like many vegetable oils, can be stored without appreciable deterioration due to natural antioxidants.

The quality of the corn can affect the resulting oil. Oil content is higher in sound corn, for instance, while free fatty acid content increases in damaged corn, resulting in increased refining losses.

According to Evelyn Weber, USDA research chemist at the University of Illinois, almost all U.S. corn is shelled in the field. Corn that is field-shelled at 20–25% moisture or higher may be chipped, cracked or bruised during harvesting, injuring the germ which is particularly susceptible to abrasion. Artificial drying of the corn may produce stress cracks in the grain, making it more susceptible to additional damage during handling. "Some of the oil may be lost or migrate to the endosperm. The oil in mechanically damaged grain is much more susceptible to deterioration by fungi or autolytic enzymes which catalyze fatty acid oxidation and triglyceride hydrolysis," Weber wrote in *Lipids in Cereal Technology.*

According to Weber, corn oil has increased in polyunsaturation by about 5–8% over the past 20 years. At the same time, average oil content of corn received at Midwest milling plants declined from about 4.8 to 4.2%. Quantity and polyunsaturation of the oil, as well as susceptibility to breakage, are influenced by the selection of corn genotypes.

## Marketing a healthy image

Consumers today readily identify Mazola and Fleischmann's as corn oil products, the result of careful marketing campaigns by their manufacturers that stress potential health benefits. While other firms may produce more corn oil, Mazola particularly has succeeded in identifying its products with corn ("We call it maize . . .").

Mazola corn oil was introduced in 1911 by the Corn Products Refining Company (which later merged with Best Foods and now is known as CPC International Inc.). Until 1940, the company's main marketing goal was to establish the brand name and build market share. Butter and lard had been the primary consumer cooking fats, and any liquid vegetable oil was a new product. To gain consumer acceptance, Best Foods produced cookbooks with recipes demonstrating how to use corn oil in cooking, baking and in salads.

Three scientific discoveries led to Mazola's positioning as a "healthful" food. First, researchers discovered that some polyunsaturated fatty acids (FAs) are essential nutrients. Second, researchers discovered that polyunsaturated FAs play an important role in serum cholesterol balance. Finally, polyunsaturated FAs were shown to be precursors for the prostaglandins.

In 1940, the company began to promote a health image for Mazola based on corn oil's essential FA content. Consumer advertising carried the message that Mazola corn oil contained a "vital food factor."

During the late 1950s, the advertising campaign was keyed to reducing serum cholesterol by substituting polyunsaturated Mazola corn oil for some of the saturated fat in the diet.

"I was working at Corn Products Refining Company when the research was being done on diet and health," recalled AOCS member Dorothy Rathmann, now retired, formerly director of nutrition and toxicology at Best Foods. "We were very impressed that the researchers were using corn oil." Corn oil had been chosen, she learned, because it was readily available and consistently of high quality.

"We started what has become a continuing program to educate consumers on the benefits of corn oil and vegetable oils in the diet. It was partly a public relations and marketing push, associating Mazola with corn oil and corn oil with beneficial health effects," Rathmann said.

A medical marketing campaign also was launched. Literature reviews on heart disease and the nutritive values of vegetable oils were offered to doctors and health professionals, partially through exhibits at meetings of the American Medical Association, the American Heart Association and the American Dietetic Association.

Since 1978, the goal has been to broaden Mazola's health image, emphasizing the potential benefits of a fat-modified diet on various heart disease risk factors. The Mazola Nutrition/Health Information Service was created to provide information to health professionals and science and medical writers through additional literature reviews and a quarterly newsletter.

Since 1956, Mazola has supported publication and distribution of 15 major literature reviews, three teaching monographs and two films for professionals. Also, Mazola produced and distributed 22 different consumer education booklets, including menu plans with recipes, exercise programs and general information on dietary fat, diet and chronic disease. In 1984, the Mazola Nutrition/Health Information Service mailed 1.9 million copies of health-related literature to professionals and consumers.

For corn oil products, nutrition and health have become effective marketing tools.

"Producers of commercial maize seed usually do not monitor the oil content or fatty acid [FA] composition of the hybrids that they sell," Weber said, adding that although environmental factors have some effect on FA composition, the principal cause of variation is genetic.

Oils from different corn cultivars have different FA compositions. For instance, according to Reiners and C. M. Gooding in *Corn: Culture, Processing, Products,* Argentinian corn oil, as well as Russian and Italian corn oils, is more saturated than that produced in the U.S.

Research by Milton D. Jellum, agronomy professor at the University of Georgia, has focused on breeding corn for FA variability. In his breeding program, Jellum has developed lines with unique FA compositions. For instance, he has achieved the following ranges for various FAs in corn cultivars he has produced: palmitic, 5–24%; stearic, 0.5% to over 20%; oleic, 15–65% and linoleic, 15–75%. Commercial corn oil in the U.S. generally is around 59% linoleic, 26.6% oleic, 11.5% palmitic, 2% stearic and 0.8% linolenic, with less than 0.5% made up of arachidic, myristic and palmitoleic acids. Last year, he released genetic material for a high stearic line (18–19%) which might be used for producing oil for hand creams and lotions. Jellum, who is to retire the end of this year, hopes to release seed from other genotypes derived from this year's crop to the national seed bank so that interested researchers can pursue this work.

## Use

Corn oil is considered a premium oil because it contains little linolenic acid, which is prone to autoxidation. Corn oil also is suitable for cooking or frying without being hydrogenated. Low cloud point and melting point, as well as good keeping qualities, make it a desired cooking oil.

Approximately 40–50% of U.S.-produced corn oil is used for cooking and salad oils, while corn oil margarine takes up another 30–35%. Liquid corn oil used in producing margarine is blended with partially hydrogenated corn, soybean or cottonseed oils. Liquid and partially hydrogenated corn oil is used in formulation of high polyunsaturated premium stick margarine and premium soft margarine. According to T. L. Mounts and R. A. Anderson in *Lipids in Cereal Technology,* a diet imitation margarine containing 40% fat is formulated with liquid and partially hydrogenated corn oil. Standard margarine contains 80% fat. In addition, a new market has opened up with the use of corn oil in a 60/40 blend of butter and corn oil. According to Brenner, corn oil margarine use stabilized around 1980 after a long period of growth. This new product, he said, promises to return some growth to this area of use.

According to USDA figures, U.S. consumption of edible corn oil totaled 692.8 million pounds between October 1983 and September 1984. Of this, 195.8 million pounds were used in margarine, while 457.6 million pounds were used as cooking and salad oil. Preliminary figures for 1984–1985, meanwhile, show the total increasing, with 505.7 million pounds already consumed between October 1984 and May 1985. According to *Commodity Yearbook* figures, corn oil's share in total margarine produced in the U.S. was 12% during 1978–1982, compared to 88% represented by soybean oil. Corn oil's share in salad and cooking oils was 7%, compared to soybean oil's 84% share and cottonseed oil's 9% share. Also, corn oil represented 1% in other food uses.

Corn oil is used in other ways in food. For instance, in Japan, according to William Shurtleff and Akiko Aoyagi in *Soymilk Industry and Market 1984,* "All dairylike soymilks contain added oil. Most use corn oil." In the U.S., corn oil also is used in many commercial baby formulas.

## Processing

Corn kernels contain approximately 4.5% oil, 85% of which is in the germ. The germ itself contains about 50% oil after steeping and degermination by the wet milling industry. Before processing, the germ of ordinary dent corn contains only about 35% oil. A bushel of shelled corn, weighing 56 pounds, can provide nearly two pounds of corn oil. Actual commercial oil yield will vary from processor to processor, depending upon the quality of corn and the manufacturing steps used.

Both wet and dry corn millers separate the germ from the corn kernel and recover oil from the germ. According to agronomist D. E. Alexander at the University of Illinois at Urbana, approximately 10–15% of the U.S. corn crop is processed through wet or dry milling. The American Corn Millers Federation, representing dry millers, estimates 10% of this year's expected 8 billion bushel corn crop will be handled by wet milling, while dry milling operations will handle an additional 1.5–2%. Corn refiners explain that because approximately half the corn crop is used on the farm for feed, the 10% used for wet milling actually represents 20% of the corn sold on the market.

In wet milling, corn is cleaned twice, then placed in stainless steel vats and soaked in water at about 50 C for 30 to 40 hours. During steeping, the kernels absorb water to more than double in size. The addition of 0.1% sulfur dioxide to the water helps prevent undesirable bacterial growth and assists in loosening the glutelin matrix within the corn. The steeping process removes solubles from the germ, increasing its oil content from about 33% to 50%. After steeping, the corn is coarsely ground, breaking loose the germ. The ground corn in a water slurry then flows to germ separators.

Cyclone separators spin the low density corn germ from the slurry.

The germ is pumped onto screens and washed to remove any free starch, then dried. A combination of mechanical and solvent processes extracts the oil from the recovered germ. The oil then is conventionally refined into finished corn oil. The germ residue, meanwhile, is used as a valuable component in animal feeds.

In dry milling, the objective is to separate from the corn valuable endosperm fractions such as grits, meal and flour, essentially free of germ and fiber. This is accomplished by first cleaning the corn, then tempering it by the controlled addition of moisture, and finally freeing the germ and hull from the endosperm in a degerming mill. This stock is separated into the desired fractions in a series of roller mills and sieves. The recovered germ fraction, containing 15–25% oil, is processed for oil recovery by either screw pressing or solvent extraction.

Crude corn oil is refined in several steps. Alkali refining removes the phospholipids and free fatty acids. Refined oil then is bleached. The oil is usually winterized as well to remove waxes. However, because wax content of corn oil is low, winterization is not used when the oil is to be hydrogenated or used for margarine production. Deodorization produces quality corn oil with low free fatty acid content, light color and good stability against oxidation.

## Production

According to *Corn Annual 1984* published by the Corn Refiners Association, "Of every six bushels sold, corn refiners buy one for processing into the syrups, starches, oil, animal feeds and alcohol." Bushels of shelled field corn travel from individual farms and elevators by truck, train and barge to 27 corn refining plants in 15 states.

In the U.S., corn oil ranks second to soybean oil in quantity of oil refined. A USDA survey of the edible fats and oils refining industry conducted during the winter of 1983/84 showed corn oil during the 1982/83 marketing year accounted for over 7% of the total fats and oil refined, surpassing cottonseed oil which accounted for 6.4%. Soybean oil led, accounting for nearly 75% of the total U.S. refined oil output.

U.S. corn oil production doubled between 1970 and 1982. In calendar year 1970, crude corn oil production totaled 474 million pounds. For the 1983/84 crop year, over 1 billion pounds were produced. Preliminary figures for the 1984/85 crop year show corn oil production continuing to increase (see Table I). Dry millers expect to produce 50 million pounds of crude corn oil from this year's crop, while wet millers estimate their production at 1.2 billion pounds of oil.

Major corn producing countries are the U.S., China, Brazil, Rumania, Russia, Yugoslavia and South Africa. Major corn exporting countries are the U.S., Argentina, South Africa, France and Thailand. Chief corn oil exporters are the U.S., The Netherlands, France, West Germany, Brazil and Argentina.

Bureau of the Census figures show that U.S. corn oil exports have increased substantially in the last few years, reaching 310.6 million pounds in 1983/84, compared to 180.5 million pounds in 1980/81 (see Table II). The principal growth markets have been in Asia and the Middle East, where corn oil is a premium product. Exports to the European Economic Community (EEC) have increased as well.

The EEC is the largest import market for corn oil. According to the German fats and oils weekly *Oil World*, the largest increases in corn oil imports outside the EEC during 1983 occurred in Saudi Arabia and Singapore.

## Breeding

Because corn is not considered an oil crop, Alexander said, breeders

**TABLE I**

**U.S. Corn Oil Production**

| | Crude corn oil (million pounds) | Once refined corn oil (million pounds) |
|---|---|---|
| Year | | |
| 1970 (Jan.–Dec.) | 474.0 | 440.9 |
| 1971 (Jan.–Dec.) | 485.1 | 440.3 |
| 1975 (Jan.–Dec.) | 458.8 | 496.6 |
| 1976 (Jan.–Dec.) | 692.4 | 562.2 |
| 1978–1979 (Oct.–Sept.) | 736.4 | 577.7 |
| 1979–1980 (Oct.–Sept.) | 791.1 | 606.2 |
| 1980–1981 (Oct.–Sept.) | 863.6 | 745.8 |
| 1981–1982 (Oct.–Sept.) | 871.5 | 709.3 |
| 1982–1983 (Oct.–Sept.) | 982.6 | 817.3 |
| 1983–1984 (Oct.–Sept.) | 1,053.0 | 908.0 |
| October 1984–July 1985 | | |
| October | 88.0 | 76.9 |
| November | 75.5 | 83.4 |
| December | 89.6 | 86.8 |
| January | 87.7 | 79.3 |
| February | 84.2 | 69.8 |
| March | 107.3 | 84.1 |
| April | 107.0 | 71.6 |
| May | 110.1 | 100.2 |
| June | 107.7 | 91.9 |
| July | 130.2 | 101.9 |

Source: Bureau of the Census

TABLE II

U.S. Corn Oil Exports—Crude and Refined

| Crop year (Oct.–Sept.) | Quantity (million pounds) | Value (million $) | Producers' value (million $) |
|---|---|---|---|
| 1980–1981 | 180.5 | 68.8 | 60.8 |
| 1981–1982 | 202.3 | 73.7 | 65.1 |
| 1982–1983 | 224.4 | 81.4 | 71.9 |
| 1983–1984 | 310.6 | 122.7 | 108.3 |

Source: Bureau of the Census

largely have ignored oil content and have selected for yield, standability, disease, insect resistance and maturity. However, oil content has not been completely overlooked in breeding research. Experiments in breeding corn for oil content were started at the University of Illinois in 1896, with Burr's White, an open-pollinated variety, being mass selected for both higher and lower percent oil. "The original level of oil was 4.7% but reached 20.4% in the 85th generation of selection. The low-oil strain apparently has reached a physiological lower limit of approximately 0.5%," Alexander said. In Illinois high-oil strain, both germ size and oil percentage increased while the endosperm and total grain weight decreased. With selection only for oil, however, the yield fell to about 30% of that of commercial hybrids.

"Unfortunately, the high-oil strain of Burr's White is of little value in breeding commercial hybrids because of its low combining ability for yield," Alexander said, adding that a more valuable strain has been produced at Illinois using wide-line nuclear magnetic resonance (NMR) spectroscopy to select generation after generation of the higher-oil kernels from a broad genetic base population. After 25 generations of selection, Alexander reported, oil reached 19.1%, a value almost as high as that of the long-term Illinois experiment. High-oil inbreds from this population yield surprisingly well in some hybrid combinations and produce 8–10% oil, Alexander said. Currently, commercial hybrids producing 6–7% oil are available in the U.S.

"A paramount question facing breeders is whether higher-oil corn is intrinsically lower in yield than conventional hybrids," he said, adding that recent data on hybrids producing 8–10% oil suggest they might yield well. Noting that higher-oil corns would be advantageous in feed for swine and chickens, Alexander said there might be problems in their wide-scale use in wet and dry milling. "The production of high fructose sugars by U.S. wet millers suggests that increases in oil or protein might not be attractive, even though corn oil is more valuable by a factor of at least three than starch, the basic raw product of high fructose sugars," he explained. "Adoption of higher-oil types for milling not only will depend on performance of hybrids, but on relative value of milled products and perhaps on costs of adapting milling machinery to accommodate their peculiarities."

According to Weber, perhaps the most significant development in breeding for higher-oil corn has been adapting wide-line NMR to nondestructive analysis of oil content. This was accomplished by Dr. Alexander and L. F. Baumann, T. F. Conway and S. A. Watson of CPC. According to Reiners, this development permits the corn breeder to plant seeds of known oil content, thus greatly shortening the time necessary to develop high-oil varieties. Also, a problem in the commercialization of high-oil corn has been the difficulty in identifying it after harvest and keeping it separate from regular corn. With the development of low cost infrared grain analyzers, a solution to this problem is in sight. Such analyzers could be used at country elevators to identify grain with higher than normal oil levels for a premium price, Weber said.

## Other Research

Other research includes work by Weber and Alexander at the University of Illinois on the vitamin E content of corn oil. Traditionally, gamma-tocopherol is the predominant form in corn. However, some families of corn analyzed showed higher alpha-tocopherol content while others had higher gamma content.

"Our research so far makes us believe it will be possible to breed for higher levels of one or the other or both forms," Weber said, adding, however, "The problem is no one yet has looked at which form would be best as an antioxidant for corn grain or the oil in storage." She said strains resulting from the research were planted this year and would be analyzed this winter, with further research planned.

Meanwhile, researchers at USDA's Northern Regional Research Center (NRRC) have looked at corn oils obtained through supercritical carbon dioxide extraction. According to NRRC's Gary List, this method produced crude corn oils as good as or better than conventionally extracted oils. The problem, however, is the practical technology for continuous supercritical carbon dioxide extraction has not yet been developed.

Other research on corn oil continues to focus on dietary questions. At the Georgia Experiment Station, Earl Worthington and Lary Hitchcock developed a method to separate various fractions of corn and peanut oils so they could study the effect of these on hardening of the arteries. Additional studies have been conducted by Josephine Miller and Worthington on rats to further examine the role of saturation and unsaturation on changes in blood cholesterol and lipoproteins.

The National Toxicology Program (NTP), meanwhile, has contracted for a number of long-term studies on corn oil. At the University of Missouri and Truman Veterans Administration Hospital, for instance,

a three-year study coordinated by Dr. Solomon E. Travis will look at the effect of vegetable oils on pancreatic hormones. In addition, NTP has contracted with Dr. Daniel S. Longnecker at Dartmouth-Hitchcock Medical Center for a five-year study on the effect of fat intake on the growth of chemically-induced pancreatic nodules, and with Dr. M. Sambasiva Rao at Northwestern University for a four-year study on vegetable oils and exocrine acinar cell lesions.

The NTP has used corn oil as a vehicle to administer toxic chemicals in rat and mouse studies. "Traditionally we use corn oil gavage for substances that need a vehicle for diet palatability and test compound stability because corn oil is convenient and considered safe. In Europe and Japan, olive oil is used as a testing vehicle because it is the common oil," Gary A. Boorman of the NTP said. However, some tests have shown more pancreatic lesions in male rats (and recent searches have found some lesions in female rats) when corn oil was used than in control rats not receiving any corn oil. "These lesions or tumors are observed only in the exocrine pancreas," Boorman said, adding that this finding has raised a number of important questions about the use of oil gavage.

"While we're classifying some of the lesions as tumors, we cannot tell what is happening biologically. Are they really tumors, that will grow if transplanted, or are they hyperplasias, that will go away if you take away the stimulus?" Boorman explained. He noted that the affected rats are also heavier than the control rats, which may be explained by the additional calories provided by the oil.

"I'd be surprised if the changes in the pancreas are due to properties specifically in corn oil. It could be due to the fat, or the calories provided," Hansen said. Citing past studies in which investigators claimed oxidized oils caused health problems in rats, Hansen said, "Some investigators didn't take into consideration that the essential fatty acids were lost in the oxidized oil. The negative results may have been due to a lack of nutrients in the diet."

Hansen, who has conducted studies on oxidized corn oils at Drexel, believes that if there is anything toxic about corn oil, it is contained in the non-urea adduct forming fraction found only in oxidized oil. "And under normal conditions, no one would eat that stuff because it wouldn't be sensorily appealing," he explained. His past work with corn oil focused on feeding oxidized oil to rats to study the effect of diet on the liver.

"My conclusion is that individual variation seems to be more important in liver function than the oil or treatment of the oil," Hansen said, adding that he would like to see researchers repeat old tests on corn oil under more realistic conditions. "I won't be surprised if the harmful effects noted earlier don't show up," he said. "I'd also like to see these tests repeated with other oils."

## Prospects

Earl Hammond of the Department of Food Technology, Iowa State University, also believes more research is needed on corn oil.

"I've often urged the corn wet milling industry to support more research on corn oil. The trouble is the industry has had very little incentive to do research as the market has always absorbed all that they could produce. Now perhaps that is changing," Hammond said, pointing to increasing competition from sunflowerseed oil and larger production of corn oil.

One area Hammond believes needs more attention is the effect of corn harvesting and storage on oil quality. "Corn currently is treated fairly roughly. The evidence indicates that this damage causes more free fatty acids, resulting in refining losses," he said, adding that finding an economic way to handle the corn more gently is a challenging problem.

Weber sees exciting possibilities for genetically altering the lipids in corn oil due to the discoveries that oil content, FA composition, FA placement in lipids, the proportions of the various lipid classes and the tocols all appear to be hereditable traits.

Meanwhile, industry watchers question whether corn oil production can continue to grow.

According to Brenner, the Corn Refiners Association believes the high fructose syrup market will continue to grow even though it is beginning to reach maturity. "We see still another year or so of growth," Brenner said. Additional corn grinding capacity has been added during the past year to meet the strong demand. Cargill Inc. has opened a new plant in Eddyville, Iowa, while CPC's Argo, Illinois facility has undergone major rebuilding and expansion.

Brenner explained that many of the current markets for primary products such as food starch grow only with population and gross national product increases. Corn refiners hope they will be able to develop new starch products for both food and industry which will increase the use of starch. Refiners also hope that the market for fuel alcohol will continue to grow, but important policy decisions on tax and trade policy must be answered before the future of this market is clear, Brenner noted. Until these are resolved, the industry is unsure if it can continue to grow at the rate of the past five years.

Admitting that the corn industry has not yet had to seek new uses for corn oil, Brenner said, "Certainly as the volume increases, there may be a need in the future to go out and find new ways to market corn oil. But it hasn't happened yet."

One avenue corn refiners may need to explore, due to increased exports of corn oil, is new trading rules for the industry. Needed, for example, are specific quality standards and terms of handling, similar to the existing rules for other vegetable oils.

Meanwhile, the industry is basking in the knowledge that the markets for corn-derived products such as starches, feeds and oils are at their highest levels ever.

"Many analysts now say that corn refining is a mature industry and that growth will come only from population growth," Corn Refiners Association chairman Charles M. Widmer wrote in *Corn Annual 1985*. He said corn refiners do not agree with that assessment. "Rather we see a bright future both for corn agriculture and corn refining based on market expansion and product innovation. Corn refiners anticipate exciting new developments in the next decade in food ingredients, fuels and octane enhancers and specialty chemical products."