# Industry News

## NSPA attacks subsidies

The U.S. National Soybean Processors Association, charging that other nations' subsidies have made the U.S.A. the world's residual supplier of soybean oil and soybean meal, has called on the U.S. government to develop new trade policies to aid U.S. soy processors exports.

Specifically, the NSPA has endorsed use of federal funds to reduce interest rates for foreign buyers of U.S. soybean oil. The federal government already has announced a program of this type.

Second, the NSPA called for at least 250,000 metric tons a year of soy oil to be moved through Title I of Public Law 480. This program is a concessional sales effort. For 1983, the federal government has said 234,000 tons (about 213,000 metric tons) of vegetable oil will be eligible for Title I, with almost all of that to be soybean oil. The NSPA noted that 10 nations that received less than a million metric tons of soybean oil under PL 480 during 1956-81, imported a total of 1.8 million metric tons during 1980-81 alone.

Third, NSPA advocated "a substantial volume of government sponsored short and medium term commercial credit" for export sales, with such credit terms becoming a permanent part of U.S. export efforts.

Finally, NSPA asked the U.S. government to seek an end to foreign governments' import and export duty differentials, subsidized financing quotas and other financial incentives.

If such measures fail to improve U.S. processors' markets, then the NSPA asks for establishment of countervailing export subsidies.

In a report accompanying its policy recommendations, NSPA notes that the U.S.A. is the world's largest producer of soybeans and has the world's most efficient processing facilities, but has consistently lost international market share since 1973-74. Outside the U.S.A., the NSPA said, 81% of the soybean crush is subsidized, 14% occurs in countries with centrally planned economies, and only 5% occurs with no identifiable subsidies.

The report notes that U.S. agricultural product embargoes in 1973, 1974, 1975 and 1980 were a factor in importing nations seeking other suppliers, which encouraged expansion of soy processing facilities worldwide. NSPA also says U.S. support of the World Bank and Asian Development Bank helped establish Malaysia's palm oil industry.

Foreign processors' 1980-81 crush totaled about 45 million metric tons, the NSPA report said, and if U.S. crush had been increased by 5.4 million metric tons, it would have meant an additional $1.6 billion in U.S. soy oil and meal exports and brought the U.S. soy processing industry to 85% of capacity, rather than the 71% of capacity that was realized. Based on USDA multipliers, NSPA said that would have meant a $5.7 billion increase in the U.S. economy, jobs for 52,200 more persons, increased personal income by $1 billion and contributed $190 million in additional federal income taxes.

## Use of antioxidants to rise

U.S. consumption of antioxidants and antiozonants, excluding their use in lubricants, functional fluids and fuels, was expected to exceed 250 million pounds valued at more than $650 million in 1982, according to Chemical Business Development Co.

The marketing research firm projects that by 1988, U.S. consumption of these materials will reach 325 million pounds, valued at $1 billion. This increase represents a yearly growth of 4.5%.

Some of the growing demand for these specialty chemicals include use to enhance the performance and extend the working life of plastics and elastomers; to improve adhesives, caulks and sealants; and to preserve food products and animal feeds.

Chemical Business Development Co. said nearly 30 billion pounds of 11 different plastics profit from the use of antioxidants.

## Louisville plant to reopen

Ralston Purina is undertaking a multi-million dollar renovation of its Louisville, Kentucky, soybean processing plant, closed since February 1981. The closing came after hexane leaked from the plant into the city's sewer system, resulting in explosions which caused extensive damage to the street and sewers in a section of the city.

Company spokesman Jim Reed said Ralston Purina hopes to reopen the plant sometime in 1984. The project includes complete renovation and state-of-the-art improvements. Reed said the plant will be used for soybean oil and meal processing when it reopens.

### Applied Science sold

Alltech Associates of Deerfield, Illinois, has purchased Applied Science Laboratories Inc. from Milton Roy Company of St. Petersburg, Florida, according to a report in Chemical Marketing Reporter. Milton Roy sold all assets except accounts receivable, according to the report.

### Kraft restructuring in Europe

Kraft Inc. has announced steps to restructure its European food operations. According to an article in The Food Institute's *Weekly Digest*, the company plans to centralize production planning, eliminate many marginally profitable

products, increase emphasis on developing higher value-added products, put in a new management team, reduce costs and do more aggressive advertising and promotion programs for Kraft Europe. The restructuring was outlined after the company saw profits were not keeping up with tonnage volume growth, the article said.

### Boll weevil in California

USDA officials have ordered cotton growers in California's Imperial Valley to plow under all cotton plant residue by Feb. 1, 1983, following the discovery of boll weevils in 11 fields there last fall.

The Imperial Valley grew about 50,000 acres of cotton this past year, a decline of more than 40% from the previous year. If the weevil becomes established in the Imperial Valley, it could next infest the San Joaquin Valley, according to a report in the *Wall St. Journal*.

### Texas port facility opens

Chemtank of Houston, Texas, has opened a $20 million marine terminal facility at Jacintoport on the Houston Ship Channel to store liquid chemicals, lube oils, vegetable oils and animal fats.

The facility has a 450,000 barrel tank storage capacity.

Gil Frank, Chemtank's marketing director, said the company expects to handle vegetable oils and animal fats for export and import. He said the chief oil to be exported would probably be cottonseed oil, with the facility also handling coconut oil, palm oil and palm kernel oil from abroad.

The facility is on a site leased from Oiltanking of Texas Inc., a Houston-based terminal company which will operate the terminal.

Chemtank's plans to increase storage capacity to over 900,000 barrels by 1986.

### Swedish firm buys Chemap

Chemap, Ltd., of Switzerland has been purchased by Cardo-Sorignona of Malmö, Sweden. Chemap, Ltd., and Process Engineering Company, Ltd., whose shares were also bought out, are being integrated in Cardo-Biotechnics, Ltd., as independent subsidiary companies.

# First Harvest of Cultivated Plantations Bringing Desert Crop Closer to Widespread Commercial Use

In 1982, U.S. commercial growers of jojoba reported their first harvests from three-year-old plants on 395 acres in Arizona and California. Yields averaged 50-64 pounds of seed per acre.

Calling this an historic turning point, Noel Vietmeyer of the National Academy of Sciences predicts, however, that it will take another five years before jojoba cultivation is more than a gamble.

A total of 25,883 acres of jojoba had been cultivated in Arizona, California and Texas on plantations of 40 acres or more, according to an October 1982 survey conducted by Carole Ann Whittaker of the Jojoba Growers Association. No figures are available for plantings on smaller acreages. An additional 1,070 commercial acres were scheduled to be planted during the fall of 1982.

Commercial cultivation of jojoba (*Simmondsia chinensis*), an evergreen shrub that grows wild in the southwestern United States and in Mexico, is still in its infancy stage. Whittaker, president of the Jojoba Growers Association says the first major commercial quantities of seed from cultivated acreage will be in 1983 when 2,500 acres are expected to be harvested.

The word jojoba, pronounced hō-hō'-ba, is a distortion of the Papago Indian word "howhowi." Jojoba also is known as bucknut, deernut, goatberry, goatnut, nutbush, pignut, quinine nut, sheepnut, lemon leaf and, more recently, by the term "liquid gold," referring to the promises made to potential investors.

Jojoba grows wild in Baja California, the southern half of Arizona, the California desert east of Los Angeles and San Diego and along almost 1,000 miles of the western half of Mexico. Its natural habitat encompasses 100,000 square miles roughly coincident with the Sonoran Desert. Its wild growth is scattered over reservation lands belonging to the San Carlos Apache, Papago, Pima and several California Indian tribes.

The commercial fields provide new employment. Harvest occurs during summer school vacation allowing teenagers to earn extra money. Work is paid for by the pound with cash on delivery to the field boss.

Jojoba plants produce soft-skinned fruit whose hulls dry to reveal hard seeds the size of small olives. The seed is composed of 45-60% liquid wax, called jojoba oil. This wax, a free-flowing liquid at temperatures above 10 C, is a mixture of linear esters of unsaturated long-chain fatty acids and fatty alcohols. This contrasts with the more common triglyceride-type plant and animal oils. Both the acid and alcohol components of jojoba oil contain principally 20 to 22 carbon atoms; each has one double bond. Waxes of this type are difficult to synthesize commercially. For decades, the only commercial source of a similar molecule was the sperm whale.

Jojoba's liquid wax can be obtained in high purity by mechanical or solvent extraction. Jojoba oil is slow to turn rancid and is undamaged by repeated heatings to high temperatures, according to an Office of Arid Land Studies, University of Arizona, fact sheet. Seeds can be stored for several years without affecting the amount or properties of the oil they contain.

A number of other plants yield saturated, solid waxes as coatings on seeds, fruits, leaves and stems, but jojoba oil is the only unsaturated liquid wax readily extractable in large quantities from a plant source, according to the National Academy of Sciences' report "Underexploited Tropical Plants with Promising Economic Values."

Jojoba has been used for more than two centuries by southwestern Indian tribes for cosmetic, food and medicinal purposes. Indians in Arizona and southern California are said to have chewed jojoba seeds to alleviate hunger. There are accounts that Indians crushed the seeds, boiled them and skimmed off the liquid wax for cooking and medicinal uses.

While scientists have long known about jojoba plants' drought resistance and versatile wax, interest in jojoba as a commercial crop did not come until the early 1970s after the United States banned imports of sperm whale products.

## Jojoba already used in cosmetics, lubricants, may be used in food products

Some promoters envisioned that jojoba could become a paying resource for southwestern Indians. Indians were encouraged to harvest the widely scattered wild jojoba plants and to try to cultivate the shrub. In 1972, more than 87,000 pounds of jojoba seeds were harvested from wild stands on the San Carlos Apache reservation and several smaller reservations in southwestern California. The liquid wax thus obtained was made available through the University of Arizona to more than 200 firms and laboratories for testing. In 1975, a National Academy of Sciences analysis of jojoba oil concluded that many industries could find uses for the oil. Koei Perfumery Company of Tokyo, meanwhile, began buying jojoba oil from the San Carlos Apache and other harvesters of wild jojoba seed for resale to Japanese cosmetic firms.

Also in the 1970s, researchers in Israel, Mexico and the U.S.A. began planting jojoba on experimental plots. Frost and severe drought in the United States killed off many of the early plantings there. It was not until 1978 that cultivated plantations of any size – 40 acres or more – were established. As jojoba plants take three to five years to produce their first harvest and at least eight years to achieve full yield potential, most of these are not yet yielding measurable harvests.

"In no case did anyone make back their growing costs in 1982," Whittaker said, referring to the first plantation harvests. "That won't happen until 1983." Whittaker's company, Hyder Jojoba Inc., with 760 acres under cultivation, plans to begin harvesting in 1983.

Jojoba had caught the attention of Israeli researchers in the 1950s when they were seeking productive plants able to survive the harshness of the Negev Desert and the salinity of the Dead Sea region. The year 1982 was the second year for commercial harvests in Israel. According to Meir Forti, researcher at the Applied Research Institute at Ben-Gurion University, at least 400 acres on commercial plantations have been established in addition to 70-75 acres on experimental plots. Four and a half tons of seed were produced on the experimental plots in 1982, Forti said.

Potential uses for jojoba range from skin care products to food to high-pressure lubricants. Jojoba oil has been found to be an effective antifoaming agent in preparing penicillin and tetracycline – with a potential use of 7.5 million pounds annually. It is used in body lotions, shampoos, skin and facial creams. Kelley Dwyer of the Jojoba Commodities Group of North Hollywood, California, says jojoba is finding increased usage in such products because it is readily ab-

Jojoba seed at two stages of maturity.

Wild jojoba among desert cacti.

In this California field, the grower has intercropped asparagus and jojoba. Asparagus protects jojoba from high winds, excessive heat and cold and produces a cash crop in its second year of growth.

# JOJOBA PRODUCTS


Jojoba oil is now found in over 300 different brand names of cosmetics in the U.S.

Those involved in jojoba product development and marketing claim the key to jojoba's future lies in its derivatives.

"There will be a certain amount of bulk jojoba oil sold to be used as is, but the future is in the forms we can change it to," says James Brown, president of Jojoba Growers & Processors Inc.

Brown and others – including jojoba pioneer researcher Thomas K. Miwa – are working on products that can be created by such processes as refining, sulfurization, hydrogenation, epoxidation, isomerization and sulphonation.

"The unique properties of jojoba oil are going to make it a success," says Dr. Miwa, who has done research and development on jojoba oil and similar wax esters for two decades. Dr. Miwa, currently a consultant and board member for Arizona Jojoba Oil and Seed Processors Inc., says, "I'm in the stage where I want to prove jojoba products are of very high quality and that they can generate profits."

"Derivatives of jojoba oil will be the products used in applications in industry," according to Brown, whose company has patented a form of jojoba butter created through isomerization.

Brown, a chemist, says studies have shown jojoba oil is a better lubricant than petrolatum but is not as good as jojoba derivatives.

"Jojoba oil when sulfurized is good for lubrication in automotive transmission and rear-end applications. In cosmetic use, hydrogenated jojoba wax will penetrate faster than jojoba oil, or, if you want the cosmetic to sit on the skin, jojoba butter is a much better product," Brown says.

Citing a number of consumer products that use jojoba derivatives for functionality, Brown says, "It's encouraging for us to see products that do not splash the word 'jojoba' across the label. Jojoba is being used for a specific function, not to promote a product as a fad."

Brown predicts that "one day, we'll see cosmetics as only less than 10% of the use of jojoba." However, he believes that is at least 10 years away. Brown believes the best possibilities for future development are in foods and lubricants.

"I think the food industry is one of the most significant future potentials for jojoba. There are companies which are not only involved in the basic nutritional research but which are doing food product development work," Brown says. Because of jojoba's stability, Brown sees it might be used as a shelf-stable margarine. "Flavorwise, there are no problems preventing its use as a salad dressing," he says.

Kelley Dwyer of Jojoba Commodities Group, North Hollywood, California, says his firm tries to communicate the potential applications of jojoba oil to industries requiring a product featuring the properties jojoba offers.

"We're now seeing the first generation of derivatives where jojoba is the feedstock," Dwyer says.

Unilever, for instance, has a patent to use hydrogenated jojoba wax as a coating for various medical preparations.

According to William Harvey Jones of Dow Chemical, Dow is interested in developing jojoba as a feedstock for other products, primarily lubricants and pharmaceuticals.

Says Brown, "There is some evidence that derivatives of jojoba oil may be more functional than the oil itself in many applications."

Meanwhile, Ronald Estefan of the Southwest Research Institute says jojoba oil is now being added to conventional crankcase oil with success and "there's no reason" it can't be used as a straight oil, with an additive. "In fact, it should need less additives than conventional oils," Estefan says, adding, however, that this needs more testing. Sulphurized jojoba oil, according to Estefan, is better than sperm whale oil as an extreme-pressure additive.

The biggest obstacle to large-scale industrial development of jojoba – inadequate supplies of jojoba oil – may be slow to change.

"The agricultural commitment to jojoba existing now will generate significant amounts of oil for consumption in industries now beginning their own research," Dwyer predicts, adding that current work on plant improvement will result in lower cost oil before 1990.

Native jojoba shrubs grow along with cactus in both the sandy plain and rocky slope terrain in the Arizona desert.

sorbed into the skin and is highly compatible with the skin's natural lubricant system. Jojoba also is marketed as a hair conditioner, although claims of miracle cures such as hair restoration have not been scientifically documented.

Early research indicated the human lipase enzymes which digest most vegetable oils and animal fats do not digest jojoba oil, letting it pass through the digestive tract largely unmetabolized. However, further research is under way on this question. Possible dietary applications for jojoba oil being considered include use of salad dressings and cooking oils and as a carrier for medical preparations which must pass through the stomach before assimilation. Meanwhile, in frying experiments, A. J. Clarke and D. M. Vermanos found jojoba oil performed comparably to soybean, safflower and sesame oils as far as flavor and stability.

A report on "Jojoba Products and Their Composition," issued by Agri Products Marketing Corporation, said jojoba oil also can be used in preparing disinfectants, surfactants, detergents, lubricants, driers, emulsifiers, resins, plasticizers, protective coatings, fibers and corrosion inhibitors.

Because of the hardness of hydrogenated jojoba wax, it has potential use in polishes for floors, furniture and automobiles; as a protective coating on fruit, food preparations, pharmaceuticals and paper containers; in lipsticks and candles. It is also seen as a possible carrier for pesticides and plant hormones or as a water-evaporation retardant.

While jojoba oil is now being studied as a renewable resource with diverse applications, it initially gained attention as a possible substitute for sperm whale oil. Environmentalists touted the arid lands plant as a possible "savior" of sperm whales.

The Office of Arid Lands Studies at the University of

Arizona says jojoba oil has the following advantages as a lubricant over sperm whale oil: (1) it has no fishy odor; (2) as a crude oil, it contains no stearins and requires little treatment for most industrial purposes while sperm whale oil has over 20% glycerides and free acids; (3) because jojoba oil is the product of a native plant of North America, its supply is not threatened by international crisis; (4) it takes up larger amounts of sulfur; (5) it does not darken on sulfurization; and (6) it does not require additives to remain liquid when sulfurized.

Jojoba molecules are slightly larger than sperm whale oil molecules. The sperm oil alcohols and acids are predominantly 14, 16 and 18-carbon atoms, while jojoba oil alcohols and acids are mostly 20 and 22-carbon atoms long. Jojoba oil is 97% wax esters whereas sperm whale oil is 75% wax esters and 20-25% triglycerides.

Jojoba oil's wax ester structure, with a *cis* stereo chemistry, makes it reactive in a variety of chemical transformations, including hydrogenation, isomerization, sulfurchlorination, epoxidation, sodium reduction and hydrolysis. Isomerization with nitrous oxide, selenium or a bleaching clay transforms a portion of the double bonds from a *cis* to a *trans* orientation, producing a thick opaque cream, known as jojoba butter. When hydrogenated, the liquid wax becomes a hard crystalline wax similar to carnauba or candelilla wax. (For a look at jojoba derivatives, see accompanying story.)

There are a number of additional materials which could be considered possible replacements for sperm whale oil or substitutes for jojoba oil.

One is Wickenol 139, synthetic

## GROWING JOJOBA

The male jojoba plant produces flowers with tiny, yellow pollen which is released into the wind and distributed over surrounding female plants.

The female flower is usually found at every other leaf node on the branches of female plants. Usually the flowers are single.

Jojoba bushes range from 2 to 15 feet tall. In California, jojoba plants grow six inches to a foot in height annually during their first ten years, assuming generally favorable growing conditions. During the first year, the root system may grow as much as two or three times as fast as the above-ground growth; one-year-old root systems may penetrate as deeply as nine feet, with root systems at maturity penetrating more than 30 feet.

Jojoba plants are either male or female and a proper mix is necessary to insure good yields. One problem with propagating jojoba from seed is that the plant's sex can't be determined until it blossoms, which usually occurs in the second or third winter. The ratio of male to female plants expected in commercial plantings from direct seeding is slightly in favor of males by 5%. Vegetative propagation would enable growers to control the density and pollinator pattern of plants in the field, thus enhancing the yield per acre. Male plants have small clusters of yellow pollen-bearing flowers while females have inconspicuous tiny silvery-green leaflike flowers which, when pollinated, develop into fruit that contain the seed. The seed is borne on new growth, with most found on the plant's outer periphery. Male plants grow faster and are usually taller and more vigorous than female plants. Crowding doesn't seem to have ill effects.

Jojoba plants have flat, oval-shaped leaves that can be characterized with a film of wax that reduces evaporation. When growing wild, jojoba usually is found in well-drained coarse mixtures of gravel and clay desert soils. Some tolerance to salt allows jojoba to grow in marginal alkaline soils.

Jojoba plants are more resistant to cold weather if subjected to the stress of less water before cold winter temperatures arrive. Researchers

recommend a hardening off period, when irrigation is withheld, before cold weather. Jojoba prospers in climates with gentle rains in the winter and spring, rather than in locations with hard, soaking summer rains. The hardiest wild jojoba plants are found in areas receiving 10-15 inches of rain a year.

Temperature may be the most critical environmental factor in growing jojoba, according to Demetrios Yermanos of the Department of Plant Science at the University of California in Riverside. During early seedling development, excessive cold can kill an entire plantation. However, mature plants can withstand desert summer high temperatures of 110 to 122 F and winter low temperatures of 17 F.

Jojoba plants are wind pollinated, with pollen traveling up to half a mile. The fruit that produces seed usually occurs singly, but may occur in clusters of up to five. If the winter of the first blooming is not too severe, some flowers will be pollinated and produce seeds about five months later, but those first seeds will amount to only a handful. Full yield doesn't occur until 10 to 12 years when the plant reaches maturity. Wild plants can produce several pounds of seed per bush; conglomerate bushes may produce 30-40 pounds on occasion. Seed size varies. There may be less than 300 seeds per pound to more than 2,500 seeds per pound. This variation does not affect oil yield, which ranges from 45-60% of the seed by weight. Assuming a 50% oil content, it would require about 20 pounds of seed to produce a gallon of jojoba oil using current extraction methods. Solvent extraction could produce a gallon of oil from as little as 14 pounds of seed.

The natural lifespan of a jojoba bush is 100 or more years.

Yermanos has noted erratic yields in wild stands of jojoba. It is not clear to what degree these fluctuations are affected by various environmental and genetic factors. Seed yield does not seem related to plant height, leaf size, branching or other growth habits, according to Yermanos.

The plantation grower's goal is to produce 5,000 to 6,000 pounds of seed per acre – a ton of oil per acre.

jojoba oil by Wickhen Products, designed to replace or extend natural jojoba oil. This product is an ester of unsaturated straight chain acids predominantly $C_{22}$ and branched chain alcohols which are predominantly $C_{20}$. Another is Scheroba Oil, marketed by Scher Chemicals Inc., of Clifton, New Jersey.

"The primary advantage of synthetic jojoba oil could be lower cost, but future lower prices of natural jojoba oil will tend to eliminate the attraction of mimic products," Dwyer said.

Another alternative material being studied is derived from the deep-sea fish species Orange Roughy found near New Zealand. In the September 1982 *JAOCS*, D. H. Buisson said tests showed sulfurized oil from the Orange Roughy is comparable to sulfurized jojoba and sperm whale oils as an extreme-pressure alternative to lubricants. In the hydrogenated form, Orange Roughy oil could substitute for hydrogenated jojoba oil, spermaceti or carnauba and candelilla wax. Buisson said production of the oil, obtained as a byproduct of the fish, could potentially be 2,500 tons a year. However, according to Takeshi Kunimoto of Koei Perfumery Company, the fishy odor of Orange Roughy oil is a deterrent to its use in cosmetics.

Other materials that have been mentioned as possible replacements for sperm whale oil can be prepared from selectively hydrogenated soybean and linseed esters, or from rapeseed, crambe and limnanthes seed. According to E. H. Pryde of USDA's Northern Regional Research Center in Peoria, Illinois, "I think any one of these materials could serve as well as jojoba oil, but they do require special processing to make the simple wax-like esters from the original triglyceride oil. This special processing raises the cost of preparing the sperm oil substitutes, but then jojoba oil isn't very cheap either. The distinctive feature of the proposed substitutes is that they consist of the ester formed from a fatty alcohol and a fatty acid, each having one double bond."

NAS' Vietmeyer, however, does not feel these are realistic alternatives. "Limnanthes, crambe, rapeseed – they're all triglycerides. You have to do some radical transformations – three big chemical changes in fact – and what you end up with is jojoba. Whether they could ever compete economically is extremely doubtful."

Up to this point, uncertainty of supply has been a major deterrent to commercial research and development. That may be changing now that growers are showing jojoba can be successfully cultivated.

"The price is still too high, so many industries aren't interested. But I feel it will come down to the range of other vegetable oils and huge markets will open up," Vietmeyer said. "As soon as chemists get their hands on it in large quantities at reasonable prices, we'll see all kinds of new products. And I believe you'll see a big change over the next three to five years. Ten years ago, all stands of jojoba were wild. Now there have been some commercial harvests, which show it can be done. This is a huge first step."

Peter Childs, president of Sunland Jojoba of Casa Grande, Arizona, agrees. His company buys and sells seed, grows jojoba as a commercial crop and operates a processing plant.

"It's very exciting – a miracle, really – to be harvesting from

three-year-old plants," Childs said. "This shows that we will be able to get seed from cultivated jojoba."

During the late 1970s, the National Academy of Sciences projected that 570 million pounds of jojoba seed would be needed to meet domestic demand between 1982 and 1993, requiring 150,000 productive acres of cultivated jojoba. A March 1980 *Venture* article said studies predicted that oil from the first 10,000 acres of cultivated jojoba in the U.S.A. would be used primarily by the higher-priced markets – cosmetics, pharmaceuticals and lubricants with unique applications. The next plantings would supply the market for specialty lubricants, for high-pressure or high-temperature machinery. After 150,000 acres are planted and producing, the article said, there should be enough jojoba oil to manufacture engine lubricants competitive with petroleum-based products. However, jojoba watchers are quick to add, the price of jojoba oil would have to drop to $1-$3 a pound to penetrate such markets.

Dwyer says acreage already planted will be producing enough seed before the decade is over to interest companies wanting to apply jojoba oil to food use, new cosmetic products and in textiles.

Prices have been unstable, a situation that is expected to continue until large plantations come into maturity. In March 1980, a gallon of jojoba oil cost $75. In 1981, prices skyrocketed to $200 a gallon. Credited were the high demand for jojoba propagation seed and low wild yields that year. Seed at that time was purchased from harvesters at $10 a pound, then resold for $25 a pound. Although some predicted the prices of jojoba oil would stabilize at $200 a gallon, it fell instead. By July 1982, prices had dropped to $75 a gallon for 55-gallon drums of jojoba oil purchased in quantity. In September, large quantities were moving at $65-70 a gallon. By March 1983, prices are expected to be in the $100-125 a gallon range. Some processors, growers and users project jojoba oil eventually will drop below $50 a gallon when peak production is reached on cultivated plantations.

## Jojoba should produce a ton of oil per acre

Waiting three to five years for any yield from a plantation means growing jojoba is no get-rich-quick scheme. This is not to say, however, that there hasn't been hype to promote jojoba as the way to fortune. Some promoters unrealistically have claimed jojoba will produce 30,000 pounds of seed per acre a year. Others promise exorbitant prices, ignoring the fact that users will choose other ingredients for their products if jojoba is too expensive, or that as supply increases, prices will drop.

In a January 1982 *Wall Street Journal* article, an investment adviser referred to jojoba as "the silver of the 1990s." About the same time, an investment advisory service picked jojoba, after real estate and rare coins, as one of the "ten best places to put your money now."

While magazine articles projected there would be harvests from cultivated plantations in the late 1970s, jojoba development has not happened that rapidly. "Private investment capital is the only capital available," Whittaker explained, adding, "Growers are running behind schedule on planting jojoba, particularly with the state of the economy.

"In a good year, which 1982 was, native stands in Mexico, California and Arizona yield a total of 500 tons of seed, producing 50,000 gallons of oil. We don't know how much to expect on a plantation." She said a low estimate would be 2,000 pounds of seed per acre from an 8- to 10-year-old plantation, with a maximum of 7,000 to 8,000 pounds an acre. A more realistic figure might be 5,000 to 6,000 pounds. "If you got 5,000 pounds of seed per acre, that would produce a ton of oil an acre," Whittaker said.

Jojoba may be propagated from seed, stem cuttings and tissue culture. Plants propagated from seed from native stands vary greatly in flowering. Some begin flowering at less than two years while others haven't flowered after seven. In a greenhouse, blooming may take place within 8 to 18 months.

"We don't have the proven varieties or selections yet," said Dr. LeMoyne Hogan, professor of horticulture at the Department of Plant Science, University of Arizona. "There's no question that's where the future lies for jojoba. But, it's going to take four to five years for cutting material to be adequately tested."

Yermanos, Department of Plant Science at the University of California, Riverside, found another possible solution: a hermaphrodite plant, with both male and female flowers. However, several more years of testing are needed to determine its

suitability for plantation use.

Agricultural consultant Amron Kadish, speaking at the Fifth International Conference on Jojoba and Its Uses in Tucson, Arizona, this past October predicted there will be hermaphroditic clones of jojoba available for growers in the next 5 to 10 years. One problem now with hermaphrodites, Kadish said, is they produce very little seed.

Research has shown seed yield varies considerably on cultivated plantations from plant to plant, location to location, year to year. Yermanos says while this may be disconcerting to growers, it offers plant breeders the opportunity to identify and propagate superior ecotypes for particular growing areas, especially where jojoba is not native.

Questions needing to be answered include optimum plant spacing, male/female ratios, disease and insect control techniques, water and fertilizer requirements and tissue culture methods. Other research objectives include determining second commercial crops to grow among the jojoba to reduce the cost burden of establishing a plantation. One grower plants asparagus in the rows between jojoba plants.

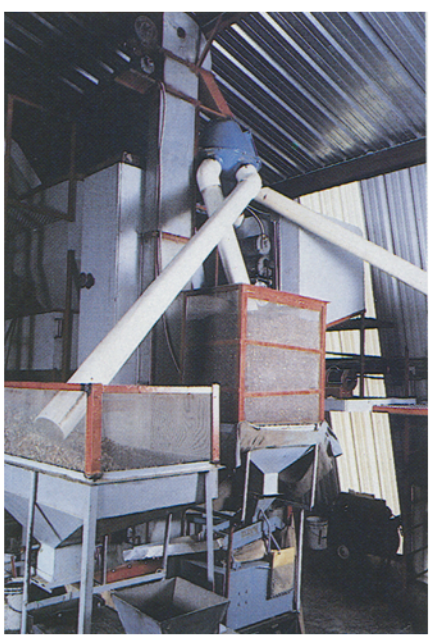
According to Whittaker, jojoba's long-term success as a domesticated crop will depend on the industry's ability to identify and propagate superior strains of jojoba which mature early, have high and stable yields, are tolerant to salt and cold, are resistant to disease and insects, and which have flowering and growth characteristics conducive to easy harvesting.

Currently, most jojoba seed is harvested by hand – a hot, tiring job. Mechanical berry and grape pickers have been tried, but do not always work well because the shape of jojoba plants varies. Most machines tested either have ruined the twigs or made the seeds fall to the ground where they must be hand picked. Jojoba Harvesters, a subsidiary of American Jojoba Industries, has come up with a mechanical harvester which it says can be used quite successfully on jojoba provided the bushes when planted are bermed with 18 inches of earth (see accompanying story).

Dr. Yermanos and others, meanwhile, suggest that pruning the shrubs is beneficial and allows seeds to be harvested from the ground by suction equipment.

Currently, the jojoba oil is obtained through hydraulic extraction, according to Childs, who believes solvent extraction will become the favored method once sufficient quantities of seed make it more economical. "You will see a pilot solvent extraction facility somewhere in Arizona during 1983," he predicted.

Among current U.S. jojoba processing facilities are Sunland in Casa Grande, Arizona, and Sonora Jojoba Seed Co. in Apache Junction, Arizona. Each claims capabilities of handling 1,000 pounds of seed per hour, or 3,000 tons a year. James Brown, president of Sonora Jojoba Seed Co. and the Jojoba Growers & Processors Inc., said



The incoming raw seed is cleaned in the separation elevator, then moves into the storage bin before entering the extraction machinery.

Jojoba Growers and Processors' facility in Apache Junction, Arizona, runs two French 33-inch presses simultaneously to process the oil, producing up to one full 55-gallon barrel in an hour. It could process all seed projected from currently planted jojoba acreage in the U.S. in about 225 days.

# DARTH VADER IN THE JOJOBA PATCH

The first mechanical jojoba harvester to be commercially available in the U.S.A. has been developed and successfully field tested.

U.S. Agri-Research of California and its affiliate, American Jojoba Industries, Inc., used the $85,000 machine during the 1982 harvest on cultivated acreage they own in California.

"We're not 100% happy with its performance, but it works quite well," said Eugene Pace, president of U.S. Agri-Research. "Unquestionably, it's at least 90% efficient." According to Pace, hired laborers generally reap no more than 90% of the seeds when they handpick. Explaining that labor cost is a primary expense for growers, Pace said, "When seed production increases, labor will become even more an issue, making a mechanical harvester the most cost-effective alternative."

The harvester was jointly developed by BEI, a South Haven, Michigan, firm, and Jojoba Harvesters, a subsidiary of American Jojoba Industries, Inc.

While other trials with harvesters have generally been unsuccessful primarily because they damage the lower sections of the plants, Pace said, "This machine does not create these problems, provided the grower spends the money to build an 18-inch berm upon which the plants will be grown. When you do that, there is plenty of room for the picker's seed-catching mechanism to go under the bush."

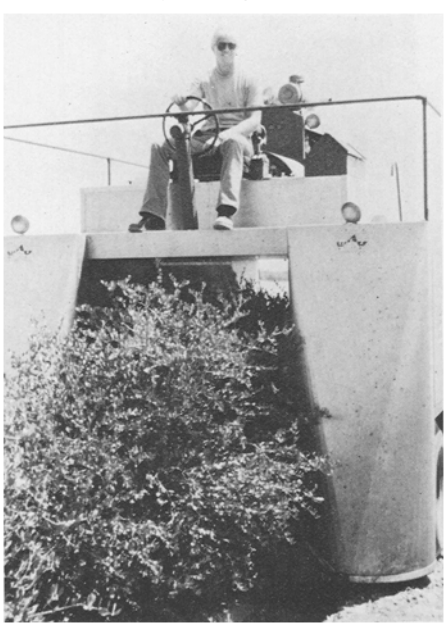
Pace's company first tested a modified grape picker during 1979 and 1980. "It beats the hell out of the plants!" Pace said. "By late 1981, we finished modifications on the newly designed picker and ran it through the field to prepare for harvesting in 1982."

"This machine is marvelous," Pace said, explaining that the grape picker, which has a beating mechanism, is designed for reaping a wine product, whereas the picking mechanism of this new machine is better suited to reaping a table product using a more delicate "jiggling" method.

The jojoba harvester, as described by Pace, looks "a little like Darth Vader." The operator is perched above the plants. As the harvesting mechanism approaches the plant, arm-like fingers penetrate the plant's growth. "They jiggle the plant up and down and back and forth," Pace said. The 240 fingers are mounted on eight limited slip cams which make the beater action less severe than that of the slapper principle used on the grape picker. "The seed falls onto collection conveyors and is fed continuously back to the main collection bin," Pace said, explaining that chaff and leaves are blown out as the seed travels back.

U.S. Agri-Research and American Jojoba Industries, Inc., the only growers using the harvester in 1982, have 2,500 cultivated acres of jojoba in California, most of which is not yet producing, and plan to develop an additional 2,000 acres in 1983.

Photo courtesy of U.S. Agri-Research and Development Corporation



Sonora handled 125 tons of seed in 1981 and plans to process a total of 200 tons from the 1982 harvest.

Currently, Childs and Brown said, the seed is run through the press twice to recover 41-42% of its weight in oil. Residual oil content in the meal is about 8-10%.

"When you're talking about such a valuable oil, that waste is foolish. That's why solvent extraction will be the answer once there's enough seed," Childs said.

With no solvent extraction infrastructure in place, several solvent options are available to the jojoba industry. One might be hexane, the most common solvent used for oilseed extraction. Another is the use of supercritical carbon dioxide which Dr. H. K. Mangold, head of the Federal Center for Lipid Research in West Germany, reports is also very effective in extracting the wax esters from jojoba. Meanwhile, Dow Chemical has been testing methylene chloride for possible use with jojoba. Willie F. Gerald of Dow's Inorganic Chemicals Department reports methylene chloride was found to extract some of the oil at room temperature and was about 98% efficient in extraction, while hexane was about 97% efficient. According to Gerald, methylene chloride requires less BTUs than hexane, allowing more meal to be processed per hour. Further studies by Dow will look at the economics of this process versus others, oil quantity comparisons, and possible extraction equipment modifications needed to use methylene chloride.

Although the meal byproduct from jojoba contains 26-32% protein as well as carbohydrate and fiber, its use as a possible livestock feed is complicated by

the presence of cyano compounds. The meal contains *simmondsin* and three related toxic substances. Laboratory rats avoid diets containing these additives. Some researchers, however, have found that the adverse effects of these cyano compounds can be countered by treating the meal with ammonia, ammoniacal hydrogen peroxide or lactobacilli. These and other studies on using jojoba meal as a livestock meal are being conducted at Anver Bioscience Design Inc. in Sierre Madre, California; the College of Agriculture, University of Arizona at Tucson; and the School of Agriculture, California Polytechnic University at Pomona, California.

Jojoba watchers say that its future depends on two crucial areas: the successful development of high-yielding strains and the marketing of jojoba oil to a variety of industries.

"It may take three times the acreage now in the ground before we have the confidence of the chemical industry," Vietmeyer said.

There are a variety of potential markets and uses still needing further development. Sunland Jojoba, for instance, hopes FDA will approve jojoba oil as a dietary ingredient as early as 1983. Since 1979, 200 jojoba-based cosmetics have appeared on the domestic and foreign market. These include shampoo, suntan lotions and skin creams. Some believe jojoba oil can be developed to treat acne.

Currently, 30% of the seed bought by companies such as Sunland and American Jojoba Industries goes for propagation. The remainder is processed for oil. Much of the oil goes into cosmetics; the rest is used for research, in lubricants, pharmaceuticals and as a hard wax.

Jojoba products are now available in some high performance automotive stores. Sunland Jojoba claims that when blended with the synthetic and natural oils, jojoba dramatically reduces friction in engines. Key Oils & Lubricants, specializing in automotive jojoba lubricants, reports superior results in reducing engine wear and improving gas mileage. Bob Anderson of Key Oils said tests show a 30-50% drop in transmission fluid heat when jojoba oil is used. Key Oils now markets a motor oil containing jojoba. Anderson and Ronald Estefan of Southwest Research Institute believe jojoba can be developed for automotive transmission and differential lubrication as well as electrical transformer lubrication. A telephone company is studying using jojoba as a lubricant in some telephone components. Meanwhile, jojoba oil is being looked at as a replacement for shark liver oil in magnetic memory media.

In other research, Westinghouse Electric Corporation, Pittsburgh, used jojoba oil as a lubricant in an experimental artificial human heart pump it designed under federal contract several years ago. However, because of the economy, Westinghouse is no longer developing fluid lubricants.

Jojoba oil's effect on blood cholesterol levels and lipoprotein is being studied. Possible food uses are being explored.

"The markets are there, they just need to see adequate production," according to Skip Stiles, assistant to Congressman George E. Brown Jr. of California. Brown has proposed legislation to create an Arid Land Renewable Agricultural Resources Corporation to provide loan and price guarantees and joint ventures for such plants and buffalo gourd and jojoba, although it has not been acted

## IN CALIFORNIA, JOJOBA TRIED AS ROADSIDE PLANTS

Some have suggested planting the shrubs for ornamental purposes and to reduce soil erosion. In southern Arizona, jojoba shrubs have been used for many years as landscape plants. In California, the California Department of Transportation planted jojoba shrubs in a number of roadside locations during the 1960s and 1970s for erosion control, and possibly commercial harvest. According to Edward N. Kress of the Office of Landscape Architecture, California Department of Transportation,

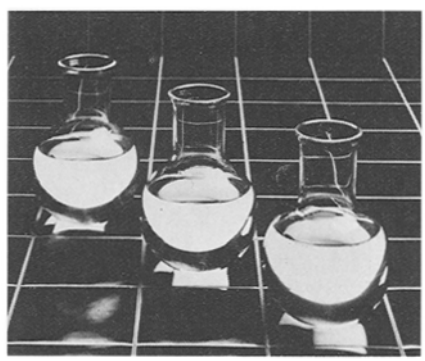
"We have fairly well determined that there would be extremely limited opportunities to grow jojoba on roadsides for harvesting due to practical problems. The results of our efforts generally have not been encouraging. The survival rate in hot interior areas without irrigation systems has been poor, even with occasional tank-truck watering. We had better success in the southern coastal areas where we established the plants with a drip irrigation system."

on. Stiles said jojoba may not even need such help.

Meanwhile, the Jojoba Growers Association, originally just for jojoba growers in Arizona, has opened its membership to jojoba growers worldwide. At the international conference in October, it announced it would take over the publication of *Jojoba Happenings* a magazine on jojoba previously published quarterly by the Office of Arid Lands Studies at the University of Arizona. Association plans include increasing the number of issues to six a year.

Childs of Sunland Jojoba said he hopes a jojoba marketing cooperative for major growers and processors will be set up in the next year or two.

"From where we sit, the future is very promising," Childs said.





EPILOGUE

## Payoff has yet to come

According to James Brown of Jojoba Growers & Processors, Inc., approximately $100 million has probably been invested in jojoba to this point – with only about $5 million in oil sold.