Feature

Expanding soybean markets, uses

The following report on research efforts under way in the U.S. to expand markets and improve soybean use was written by JAOCS *News Editor Barbara Fitch Haumann.*

Value-added products and soybean varieties tailored to produce specific end products are among the promising developments envisioned to expand markets for U.S. soybeans.

"One product such as soymilk won't make much of a difference, but if you have 25 special products or uses for soybeans, it will be highly effective in increasing soybean use," professor Alvin Nelson of the International Soybean Program (INTSOY), University of Illinois, said.

Already, genetic research conducted by U.S. Department of Agriculture (USDA) Agricultural Research Service (ARS) scientists and researchers at universities throughout the U.S. is producing soybeans that can be tailored for specialty markets. Other researchers are developing value-added products such as dairy analogs and snacks from soybeans. Meanwhile, the American Soybean Association (ASA) is promoting use of soybean oil in printing inks and as a grain dust suppressant and is encouraging feeding trials in other nations to prove the value of using soybean meal for livestock and poultry feed.

"We are interested in any use that will expand the market and the price of soybeans," Keith Smith, staff vice president of research for ASA, said. Noting that some uses would be major markets for soybeans while others would be minor markets, Smith said, "If we get a few base hits, we will stay in the game."

Smith categorized grain dust control, soy oil printing inks, the use of soybean meal in dairy rations and improved use of soybean meal in poultry rations as major markets. Smaller, but significant, markets would include use in aquaculture and in pet foods.

"Aquaculture—raising fish such as shrimp, catfish and trout—is a growing industry in the U.S. and abroad," he noted.

The switch from mainly production research to more utilization research occurred eight to nine years ago, Smith said, stating that 60% of ASA's total research money in the past six years has gone for utilization research. "U.S. soybean growers have been very supportive of utilization research," he said.

Genetic research

Research projects include modification of soybean genes to improve the fatty acid content of the oil and studies to determine the factors that influence oil and protein content. Work also is under way to develop a quick, low-cost method to determine oil and protein content.

ASA is funding research to develop biotechniques to allow gene transfer into existing soybean lines. Currently, it is possible to transform soybean cells with foreign genes. However, these cells have yet to be regenerated into intact plants. Conversely, untransformed soybean cell have been regenerated. Researchers say it is reasonable to expect that it soon will be possible to put these two together. "The ability to genetically alter commercial cultivars by gene transfer in the laboratory could result in soybean varieties with improved oil composition and eventually allow buyers to purchase soybeans tailored to specific needs," Smith said.

Such research is under way at Iowa State University, Purdue University, University of Kentucky, North Carolina State University and the University of Illinois.

- Researchers at North Carolina State, Iowa State and Purdue universities are developing high-yielding soybean lines with lower levels of linolenic acid. Oil from such lines could offer better stability and require less processing, ASA points out.
- University of Illinois researchers have identified soybean plant enzymes that regulate oil and protein production. Now they are trying to develop plants that could be specifically tailored for the protein or oil market by genetically controlling oil or protein content.
- At Purdue, ARS research geneticist Niels Nielsen is working with soybean breeders to develop lines free of lipoxygenase enzymes. Soymilk and flours produced from the new seeds are rated significantly better in flavor and aroma. Such varieties could open new markets for soy products.

A USDA/ARS research team at North Carolina State University this year released three low-linolenic germplasm lines. "There's a lot of interest in these," Richard Wilson, and ARS lipid biochemist at North Carolina, said. He noted that samples were sent to 25 companies that will make varieties from the germplasm in the U.S. and overseas. "We're now certain we know how to alter fatty acid composition," Wilson added.

Wilson said the North Carolina research team consists of microbiologists, plant breeders, physi-

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Sing-Wood Yeh at the University of Illinois makes soymilk, which can be used as a base for soy "ice cream" and soy yogurt (photo courtesy of INTSOY, University of Illinois).

Soybeans around the world

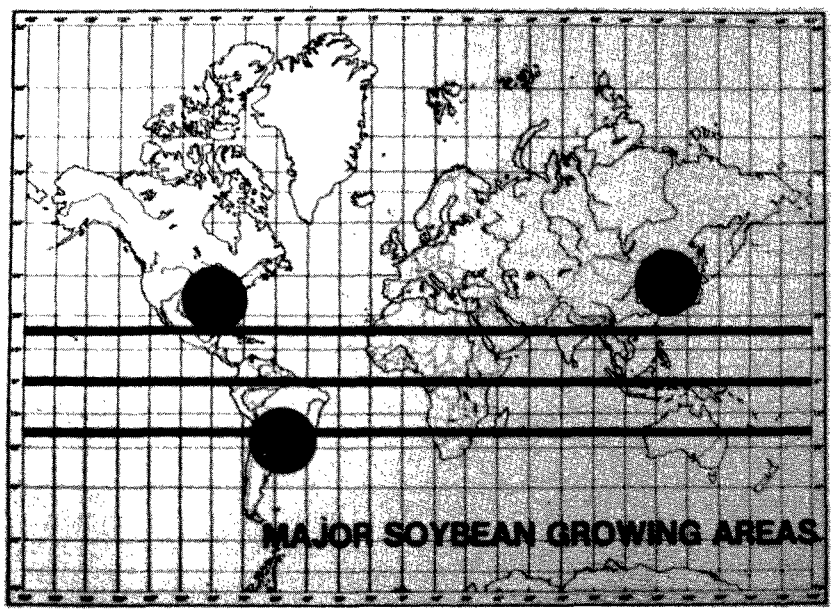
The U.S. remains by far the largest producer of soybeans in the world. However, Brazil, the second largest producer, has evolved as the largest exporter of soybean meal and oil.

The other top producers are China, in third place; Argentina, in fourth place; and India, which recently made the top five. Indonesia is in sixth place.

Italy's production has grown substantially in recent years to make it the most important soybean-producing area in Europe. Other European producers include France and Spain.

Soybeans also are grown in Australia, Canada, Colombia, Costa Rica, Egypt, Hungary, Japan, Korea, Mexico, Nigeria, Pakistan, Paraguay, Peru, the Philippines, Romania, Sri Lanka, Thailand, Turkey, Uruguay, Yugoslavia, Zambia and Zimbabwe. While soybeans are grown on a large-scale in temperate regions as a source for edible oil and protein meal, INTSOY's trials undertaken during the 1970s showed that soybeans with high yields could be grown as a food crop in the tropics and subtropics. They can adapt to equatorial rain forests, craggy mountain terraces or sparce semi-arid lowlands. All countries in South America and most in Africa have been able to grow soybeans.

According to *Oil World Annual* published by ISTA Mielke, West Germany, the top 10 soybean oil producers for 1986/87 (in metric tons) were the following: U.S., 5,430,000; Brazil, 2,538,000; Argentina, 780,000; Japan, 715,000; China, 679,000; West Germany, 521,000; The Netherlands, 488,000; Spain, 421,000; Italy, 350,000; and Mexico, 336,000. These 10 accounted for about 12.3 MT of the world's 14.8 million MT produced. (Map courtesy of INTSOY, University of Illinois.)



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ologists, lipid biochemists and protein biochemists. "We are one of a few groups in the U.S. using a multidisciplinary approach to tackle problems dealing with oil and protein and other quantitative [multigenic] traits in soybeans," he said.

Researchers there already have had success in developing high protein soybeans with high yields. "We are hopeful that within two years, we will have germplasm available for production of high-protein, high-yield varieties," Wilson said, adding that the team is developing a line with 46% protein. "High protein soybeans with high yield is a breakthrough because these traits usually are negatively correlated in soybeans," he said.

In addition, plant breeder J.W. Burton at North Carolina has been able to vary the oil content from 15% to 27%.

Other "frontiers to tackle, Wilson said, include

- incorporating the low linolenic characteristic with high protein and high yield lines.
- reducing the palmitic content to obtain a total saturated content below 5%. "We know it's feasible," Wilson said.
- incorporating low palmitic content with low linolenic content.
- incorporating low palmitic and low linolenic content with a high oleic line. "The most important use for this might be food products. Soybean oil low in saturates should be better healthwise and, with low linolenic, should be less costly to process. A low palmitic and high oleic combination also should be cost effective for the oleochemicals industry," Wilson said.
- making available 17% linolenic content (Wilson said a range of 3-17% is now possible) if there is demand for soybean oil in paint.

"We've believed for a long time that farmers and industry needed something new with soybeans—some specialty products, something unique. By changing the composition of the seed, we've shown that it can be done," Wilson said.

At Iowa State, efforts include developing varieties low in linolenic,

high in stearic, high in oleic or high in palmitic acids.

"Each has a potential new use. We have not had any modified oil type that industry has told us to produce a million bushels of, but there is interest in this work by industry," according to Walter Fehr, professor of agronomy at Iowa State.

Fehr and Earl Hammond, also at Iowa State, said researchers have produced a 28% stearic acid germplasm line, but farmers currently aren't growing it because there is no market for the oil. In addition, Iowa State hopes to have a low linolenic acid variety and a high palmitic variety available within a few years, Fehr added.

Noting that the research is supported by money from Iowa farmers, Fehr said, "They are gambling their money on this. They believe it is important and will pay off." In fact, samples of the modified oil types are being examined by industry. According to Hammond, the high stearic oil, for instance, may be useful in making non-hydrogenated shortening or margarine or as a frying oil.

Jim Wilcox, a USDA/ARS research geneticist at Purdue University, said research there has included work on fatty acid synthesis to determine how much variability can be achieved. Through mutating Century, a high-yielding variety, Purdue researchers have obtained a strain with half the normal linolenic acid content, another which is high in palmitic and a third which is low in palmitic acid. "These have been single gene changes," Wilcox noted.

In addition, his team has developed a strain high in stearic and another with a reciprocal relationship between oleic acid and linoleate; these have yet to be characterized genetically. "Characteristics are being developed to help soybean oil remain competitive in the market," Wilcox said, adding that this research will continue.

Other work at Purdue includes increasing the seed protein content and incorporating this trait in high-yielding varieties. "Most have 40% protein, but we have some strains in the germplasm with 50% protein," Wilcox said. While there usually is an inverse relationship between total protein and yield, Wilcox has obtained high-yielding experimental lines with 46% and higher protein.

Meanwhile, Professor Nielsen and his research group at Purdue are genetically engineering soybean storage protein. "Our major objective is to improve the nutritional quality of the major soy storage proteins by increasing sulfur amino acid content," Nielsen said. "We have learned to synthesize and assemble these proteins in a test tube. We're using this technique as an assay to see what effect changing the amino acid sequence has on the assembly of these complexes. The idea is to find constructions where the structure does not perturb the assembly process," he added.

Nielsen noted that the methodology already has resulted in doubling and tripling the methionine content of selected storage protein subunits. "We're hopeful that better constructions can be made and that the means of introducing these manipulated chains into soybeans can be found," he said.

At the University of Kentucky, meanwhile, David Hildebrand, a biochemical geneticist, also is working on genetic engineering of soybeans. He and colleagues Elizabeth Williams, Glenn Collins and Todd Pfeiffer are perfecting foreign gene transfer systems for soybeans and are beginning to insert genes to improve oil and protein quality. The goal is to learn how to transform and regenerate soybeans routinely.

Soy oil ink

Other research work with soybeans has focused on new uses. For instance, printing ink made from soybean oil has the potential to use 300 million pounds of soybean oil a year in the U.S., which equals oil from 28 million bushels of soybeans, according to ASA.

Soybean oil-based ink has been developed by the American Newspaper Publisher's Association (ANPA). According to George Cashau, ANPA's director of technical research, ANPA began seeking alternative sources to petroleum for ink seven years ago due to problems with petroleum supplies. First experiments focused on inks using tall oil, various fatty acids and a synthetic fatty acid; the resulting inks then were patented by ANPA. Four years ago, with fluctuations in supplies and price, ANPA began considering the use of soybean oil ink.

Pleased with the results, ANPA has filed a soy ink patent application and has begun licensing major ink

manufacturers to make it. The first ink manufacturer to produce the ink, colored and black, is General Printing Ink, a division of Sun Chemical Corp., located in Carlstadt, New Jersey.

The Cedar Rapids Gazette and its Iowa farm tabloid, *Iowa Farmer Today*, were among the first newspapers to test the new soy ink. The *Gazette* used the ink full-time and now is awaiting a new batch with improved rub characteristics; the Syracuse, New York *Herald Journal* also has since ordered production quantities. "Thirty to 40 have tried the soy ink kits," Cashau said, noting, "This is out of the laboratory stage and in the production pilot plant stage now."

One advantage of soy oil ink is, that it is environmentally nonhazardous, which could reduce waste disposal problems. The new ink also is a domestically produced alternative and thus eliminates dependence on petroleum. According to Cashau, it provides more consistent high quality, causing less "ruboff" and better coverage, than conventional ink. "It gives better mileage; the same amount of ink will print more pages when you use soy oil ink," Cashau said.

One drawback currently is that black ink made from soybean oil costs more than traditional black ink. However, according to Mike Jones of Sun Chemical Corp., there is not much price difference with colored ink. "This is because the black ink has lower pigment content and higher oil content than color ink," Jones explained.

Jones agreed with Cashau's assessment of the soy inks. "The finished product is higher quality, particularly in the color inks," he said.

Sun Chemical Corp. has integrated the soy ink into its newspaper printing ink lines and is researching soy ink application to heat-set ink products used for 95% of all magazines and journals. "It appears the oil will be applicable to this use, too," Jones said, adding, "We believe that soybean oil can be used. It's a matter of getting the right chemical balance for the process, and that's just a matter of time."

The parent company of Sun Chemical is Dianippon Ink & Chemicals, headquartered in Japan. "We sell 20% of the ink in the world," Jones said, adding that soy ink's potential market could be worldwide.

According to Cashau, if soy oil ink use becomes standard, newspapers alone could consume about 300 million pounds of soybean oil a year. Oil content in newspaper ink can be as much as 80%, and averages about 70%, Cashau said.

Grain dust suppressant

Technology using soybean oil for controlling dust in grain elevators opens another market for soybeans.

Seen as a cheaper way to control grain dust, this offers a potential U.S. market for an additional 250 million pounds of soybean oil, the equivalent of 23.4 million bushels of soybeans, according to ASA.

A recent two-year study showed soybean oil could replace or greatly reduce the need for conventional dust collection equipment or replace the food-grade mineral oil that some grain elevators and other grain handlers have begun using. The study was a joint effort by ASA, the National Grain & Feed Association and the U.S. Department of Agriculture.

Since 1982, edible mineral oil has been approved for use in suppressing dust in the U.S., with a 200 parts per million upper concentration limit set by the Food and Drug Administration (FDA). In an announcement published in the March 4, 1987, *Federal Register*, the U.S. Federal Grain Inspection Service (FGIS) ruled that soybean and other edible oils may be used to control grain dust in elevators. The FGIS ruling cited previous approval by the FDA that soybean oil and soybean lecithin are generally recognized as safe and can be applied to grains, FGIS said that addition of oil for dust control must be noted on the inspection certificate.

The FGIS ruling came on the heels of an ASA request that the U.S. Patent, licensed to Industrial Fumigant Co., is held jointly by Harold N. Barham and Harold N. Barham Jr. of Seed Technology of Texas. The patent was filed in 1978. ASA noted that fats and oils have a long history of use as dust suppressants prior to the 1978 filing. ASA says the patent doesn't meet the basic requirements of novelty and nonobvious use and that the patent's description of a "synergistic effect" by which oil affects dust is inaccurate.

In June, the patent office agreed to review the patent. If the patent is declared invalid, it would allow unrestricted use of soybean oil for dust control.

Such use of soybean oil also is being tried outside the U.S. According to ASA, soybean oil is being used as a "dust-buster" at a major grain-handling facility in Istanbul, Turkey. ASA consultant Tom Hegadorn helped show elevator managers and other grain handlers in Turkey how to install an inexpensive dust control system that uses soybean oil to suppress grain dust.

Soybean oil's use as an adjuvant to and carrier for pesticides, meanwhile, needs further research and approval, Smith said.

Iron in hulls

An additional potential market for soybean hulls would be as a source of iron and fiber for fortifying breads and other baked products.

Biochemist Joseph Laszlo at the USDA/ARS Northern Regional Research Center (NRRC) in Peoria, Illinois, has identified iron II (ferrous iron), a highly nutritional form of dietary iron in an intermediate state of oxidation and is readily digestible, versus iron III (ferric iron), the type which predominates in high-fiber plants. Iron III binds tightly to plant fiber and other food components, making it difficult for humans to absorb.

Laszlo has found that soybean hull iron can withstand high temperatures, indicating it could be used as a source of iron in baking flours and doughs.

Other research

At Cornell University in Ithaca, New York, John Kinsella is continuing research on the physical properties of soy proteins and their

current and potential uses as ingredients in food products.

Flavor chemistry is still an area of interest. "Certainly there has been marked improvement in the last six to 10 years in the flaver of the soy flour and soy concentrates. But we continue to examine the interactions of the off-flavors with the proteins and develop methods to minimize these interactions," Kinsella, director of the Institute of Food Science at Cornell, said.

Another research area gaining interest is the nutritional impact of linolenic acid in soybean oil. "We're among the many centers doing research on this question as there is much interest in the area of omega-3 fatty acids," Kinsella said, explaining, "We're studying whether linolenic acid in soybean oil is effective as a dietary source to increase tissue levels of omega-3 fatty acids. If so, it may be desirable to develop soybean cultivars with high omega-3 fatty acid levels."

This area is also under investigation at NRRC, under the coordination of Ed Emken. "Our approach is to use stable isotopes in human feeding studies. This makes our research unique, in that few other investigators have the technique to monitor the metabolic fate of dietary fatty acids in human feeding studies," according to Timothy Mounts, leader of vegetable oil research at NRRC.

Meanwhile, John W. Erdman Jr., of the University of Illinois' Department of Food Science, continues to look at nutritional aspects of soybeans, chiefly the bioavailability of minerals. His recent work with coworker Angela Poneros has investigated the calcium bioavailability from tofu. "Rat studies showed the calcium bioavailability in tofu turned out to be equivalent with that from nonfat dry milk for rats," Erdman said.

Currently, he is studying zinc bioavailability from soybean products. "I want to nail down the factors that lower zinc bioavailability," Erdman said, noting that zinc bioavailability from soybeans is lower than that from meat products. "We want to find out why this happens and if we can increase it."

At Michigan State University, John Ohlrogge is conducting research on the acyl carrier protein (ACP) gene involved in soybean oil synthesis, a project he firs started when at NRRC. This research focuses on the capability of controlling the oil content so that eventually farmers may be able to grow soybeans that produce more protein in years when demand is up for protein, or soybeans higher in oil, if that is what the market demands, Mounts said.

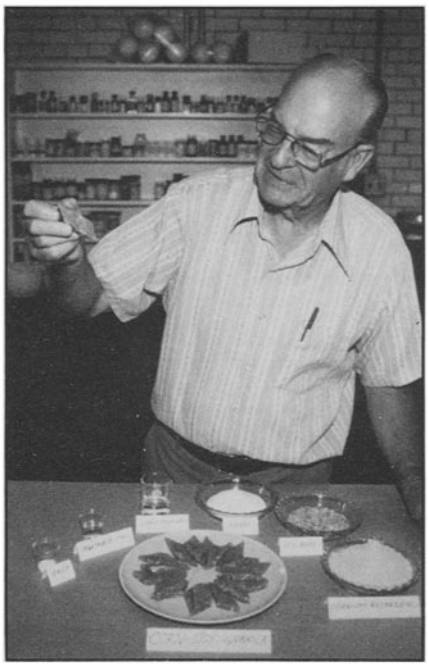
Meanwhile, Tsung-min Kuo, at NRRC, is working on genetically modifying the carbohydrates in soybeans to enhance the energy content of soymeal as an animal

feed. Other work at NRRC continues on oil stability research, to maintain soybean oil's market share. One aspect is the oil's light stability, Mounts said. "In the past, research showed the most light-stable oil was that packaged in opaque containers. However, industry is saying it wants to use clear glass or plastic. So it asks, 'How can we best keep, the oil stable?' " he said.

This work also compares the stability of soybean oil to other oils, such as canola. Mounts said that research has shown little difference between the flavor stability of soybean oil and canola oil when stored in the dark; however, canola has better flavor stability than soybean oil after light exposure. "We're trying to understand why this is true," Mounts said, noting that the addition of beta-carotene to finished oils may improve light stability.

Value-added products

INTSOY researchers, meanwhile, are working in collaboration with University of Illinois food scientists in Urbana, Illinois, to develop a broad range of value-added products from soybeans. Heading the research is emeritus food science professor Alvin Nelson, who came out of retirement for the project.



Professor Alvin Nelson of INTSOY holds up a corn-soy granola bar, one of the high protein products produced through extrusion cooking (photo courtesy of INTSOY, University of Illinois).

Products developed include

- diary analogs such as soymilk, soy yogurt and soy "ice cream."
- immature green soybeans for use as a commercially viable high-protein green vegetable.
- snack foods, breakfast foods, soups and soy-enriched additives prepared through extrusion cooking.

As part of their work, INTSOY researchers are working with small-scale extrusion cooking equipment to condition soybeans before expelling. The extruder, producing heat by friction under pressure, breaks down the oil-bearing tissues in a fraction of the time required for conventional conditional methods, Nelson said. The beans remain in the extruder system for less than 30 seconds, reaching a temperature of about 275 F. The resulting semifluid extrudate is immediately fed into an expeller.

The objective of the research has been to produce a low-fat cake or meal suitable for human food use. According to Nelson, the short cooking time at high temperature is enough to destroy anti-nutritional agents such as the trypsin inhibitor but not long enough to damage the protein or other nutritional components. Also, this treatment produces partially defatted cake which grinds very well in both conventional plate and hammer mills and a high quality natural oil requiring little further processing. The extruder-expeller combination has potential for decentralized processing in areas where smaller amounts of soybeans are produced and also opens up soybean processing to individual farmers and entrepreneurs interested in marketing edible oil and protein-rich soyfoods. According to Nelson, it also could be used to produce "natural" vegetable oil which would find demand in the domestic health food industry.

"The oil also could be used for baking and for cooking snack foods, as it gives a good brown color and flavor," Nelson said, noting there has been interest expressed in the system. "It will take a while before this is put into use commercially in the U.S.," he said, adding, "This will pose no threat to the solvent extraction industry, but rather will be an adjunct."

Researchers at Illinois have ground the resulting solids from extruded and expelled soybeans into flour and used this, mixed with wheat or other cereal flower, in bread and cookies. "The soy flour has to be mixed with wheat or cereal flour because there is no starch in the soy flour," according to research associate Wilmot Wijeratne. They also have mixed soybean and corn solids or soy and rice solids; they then have extruded the blends to produce snack "chips" with 20% protein content and about one-third the fat of conventional chips. "We can produce nice-tasting products with a good amino acid balance," Nelson said. Their aim is not to develop the ultimate product but to develop the concept for making the products, he said.

In addition, Wijeratne has worked on preparing green soybeans to be eaten as cooked vegetables. The beans are blanched and then frozen. Freezing appears to denature the protein to improve the texture so the beans then need only a few minutes to cook. The resulting vegetable has double the protein of lima beans or peas. Research now is under way to improve harvesting techniques of the green soybeans and ways to break open the pods during processing. According to Nelson, Pillsbury, which owns Green Giant Co., has been working on this project with INTSOY. Joan of Arc, a Pillsbury company and processor of canned vegetables, also is interested. "There is tremendous potential for oriental dishes made from these soybeans," Nelson said.

This could create a new vegetable crop for U.S. farmers and a market for millions of pounds of soybeans, Nelson said. Consumers would buy the soybeans in the frozen vegetable section of supermarkets, he noted.

Team member Sing-Wood Yeh is in charge of making soymilk and dairy analogs such as soy yogurt and soy "ice cream." He is refining a patented process for making

soymilk without the beany flavor. Spin-off product flavors include orange and lime sherbet, six flavors of ice cream and four flavors of yogurt, each containing a protein content of about 4% and no cholesterol.

According to Yeh, a Chicago, Illinois, company commercially makes a soy yogurt based on the Illinois method and already there are at least 50 companies making soy "ice cream," most made from tofu. At the University of Illinois, however, soy "ice creams" are made using soymilk. "Certainly these are good for people in other countries, but there's a market here in the U.S. More and more people in this country are buying products in health food stores," Nelson said.

Other value-added edible soybean products also are being commercially produced in the U.S. For instance, Iowa Nuts Inc. of Spencer, Iowa, manufacturers a processed soybean snack food that looks like a split Virginia peanut but has twice the nutritional value. The snacks, which are halved soybeans, are available in four flavors: sour cream and onion, chedder and bacon, nacho cheese and barbecue. According to Don Alger, company vice-president, the soy snacks have been sold in Iowa since May 1986, with 90% of distribution through supermarkets. The product also is sold in convenience stores, gas stations and restaurants in Iowa.

"We suggest that they be sold in the snack section, along with potato chips and other snack foods," Alger said. The snacks have fewer calories than peanuts or other nuts and are priced lower. Iowa Nuts would soon like to expand its marketing to other parts of the U.S. A number of national distributors have expressed interest in handling the line, Alger said, noting the company can produce just under a semi-truck load in an eight-hour shift. "Packaging is our only limiting factor right now," he said. The company also has developed diced butter caramel-coated soybeans for use as a dessert topping and is working on packaging techniques for marketing it.

Other U.S. companies are stepping up value-added soy product production. For instance, Central Soya Inc. is expanding its soy protein business due to a rapidly growing market for value-added soy-based products. Earlier this year, the company announced it would expand its Gibson City, Illinois, plant, increasing the company's capacity to produce traditional soy protein concentrates by 25%.

Meanwhile, tofu products such

as Jofu, a tofu-based yogurtlike product introduced by Tomsun Foods Inc. of Greenfield, Massachusetts, to compete in the yogurt business, are on the market. Another such product, Tofulicious, which is a non-dairy frozen dessert, was developed through research coordinated by University of Minnesota food scientist William Breene and funded by the Minnesota Soybean Research and Promotion Council. The product is sold by Eastern Foods Co. in Minneapolis.

In addition, the "Bean Boosters," organized by the Illinois Soybean Program Operating Board, is promoting domestic consumption of new meat products using soybeans. The group introduced soy-reinforced meats at the 1987 Illinois State Fair. The 80% meat products included tacos, pork hot dogs, lamb bratwurst and beef barbecue, all with most of the fat removed and replaced with textured soy protein.

Abroad, ASA has been promoting soy-fortified foods. For instance, in Venezuela three years ago, ASA launched an education program for consumer groups and government agencies on the benefits of soy protein. As a result, soy-fortified foods are available in Venezuela's major supermarkets, and demand for soy protein has increased to more than 48,000 pounds per month. By 1990, ASA estimates this market may grow to 1.2 million pounds per month.

Soymeal as feed

In addition, work continues to promote soybean meal's use in animal feeding. ASA has undertaken a number of feeding trials in various countries to prove the value of using soybean meal in rations. These include trials with poultry, dairy, swine, sheep, rabbits and in aquaculture.

In Taiwan, ASA has promoted the use of soymeal in duck feeds. Nine years ago, ASA/Taiwan began feeding trials to show duck producers that soybean meal is an economical source of protein and performs as well as fish meal. By 1986 Taiwan's duck producers were using soymeal to make up 25% of duck feeds, requiring almost 2.5 million bushels of U.S. soybeans.

Also, eel and shrimp producers in Taiwan are using more soymeal and less fish meal in feed, according to ASA. ASA-sponsored feeding trials at the Taiwan Fisheries Research Institute showed how to cut feed costs by using less expensive soymeal as protein. The aquaculture industry in Taiwan uses about 2 million bushels of soymeal each year. Because of the feeding trials, ASA predicts soymeal use in eel and shrimp feed will soon double to four million bushels.

During 1987, ASA reached an agreement with the Soviet Union to sponsor a swine feeding trial in the U.S.S.R. The feeding trial, scheduled in the Ukraine, is intended to show the benefits of combining domestically produced high-moisture corn with 44% U.S. soymeal to make a cost-efficient ration by fully using the energy of the local corn.

Japan also is seen as a growing market for soymeal. Currently, poultry producers are learning to cut costs by replacing traditional fish meal with soymeal in feeds in ASA-sponsored poultry feeding trials. If poultry producers replaced 2% of the fish meal used in poultry feed with soymeal, ASA predicts this would increase Japan's demand for soybeans by 14 million bushels a year.

Sheep farmers in Spain are learning about using soybean meal in feeding trials aimed at producing meatier sheep. Meanwhile in Turkey, poultry producers are calling for more U.S. soybeans to feed their flocks because of growing consumer demand for fried chicken, a relatively new food product. Rabbit-raising also is a potential market for soybeans, particulary in Europe, ASA said.

ASA checkoff-funded research has shown that 50-60% soybean meal can be used in shrimp feeds without decrease in growth or survival rates of the shrimp. Research also has shown the economics of using soybean meal are superior to fish meal, according to ASA.

In the U.S., catfish feed was a 3.4 million bushel market for U.S. soybean farmers in 1985, with almost 200 million tons of U.S. farm-raised catfish sold that year. Use of indoor, climate-controlled growing tanks could enable producers to set up indoor catfish farms anywhere in the world, offering another potential market for soybean meal. According to USDA statistics, catfish farming in the U.S. is booming. The amount of catfish processed increased elevenfold between 1976 and 1986, from less than 19 million pounds to nearly 212 million pounds.

In Spain, aquaculture specialists are developing a soymeal-based feed for commercially raised sea bass, seabream and turbot with help from U.S. soybean farmers. ASA is sponsoring marine fish feeding trials to develop more demand for soymeal. According to ASA, fish feed could eventually generate a market in Spain for 500,000 MT of soybean meal, equivalent to 23 million bushels of soybeans.

Another area where ASA would like to increase soybean meal sales is Korea, one of the most rapidly developing soybean markets in Asia. Korea purchased 35.8 million bushels of U.S. soybeans in 1986, compared to 15.3 million bushels in 1979, the year ASA opened its office in Seoul. Current Korean soybean meal demand outpaces demand for soybean oil. However, while more than 98% of Korea's soybean needs are supplied by the U.S., the U.S. supplies less than 40% of Korea's soybean meal requirements, ASA noted.

Improved methods

Meanwhile, standardized methods are of interest in the industry. Soybean researchers and industry representatives met early in 1987 for a workshop on standardization of NIR (near-infrared spectroscopy) as a measure of protein and oil content of soybeans. NIT already is successfully used to measure grain and forage composition, ASA noted. If NIR were adopted as a standard by the industry, soybeans eventually could be purchased based on protein and oil content, it added.

At NRRC, NIR routinely is used to evaluate germplasm collection, Mounts noted. "It is used to analyze 10,000 to 15,000 samples a

year at our center. We use it as a standard. The next step will be to move it out of the research mode and move it to the elevators," he said.

Mounts said NRRC researchers have found that NIR analysis of soybean meal for fat provides a good correlation for predicting free fatty acid content of the extracted crude oil.

Other concerns

Shipping quality of U.S. soybeans to compete in export markets has become a concern in recent years. As a result, NRRC researchers continue to study the quality of shipments to Europe from different locations. According to Mounts, the two-year study will be completed in February 1988 and will cover two full crop years of Brazilian and Argentina soybeans and a third year of U.S. soybeans. The study includes 12 shipments of 1986-crop U.S. soybeans and eight shipments of 1985-crop U.S. soybeans, Mounts said.

Course in soy processing

The International Soybean Program (INTSOY) will hold a month-long training program on soybean processing for food uses in January 1988 in Sri Lanka.

The course, designed to teach the principles of preparing human foods from soybeans, emphasizes the range of innovative food products that can be made from whole soybeans. It covers small-scale industrial processing and preparation methods based on home and village technology. INTSOY staff and members of the Soybean Foods Research Centrat Gannoruwa, Sri Lanka, will teach the course.

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Thus far, samples have been evaluated from shipments received at Rotterdam, the Netherlands; Ghent, Belgium; Hamburg, West Germany; Amsterdam, the Netherlands; and Lisbon, Portugal, and originating from the U.S., Brazil and Argentina. Quality analyses included protein, oil, free fatty acid, fatty acid composition, totox (oxidative) value, color, phosphatides and grading evaluation, including foreign material content and damage.

Mounts said there is some interest in extending the study by also sampling shipments received in Japan, Korea and Taiwan.