Feature


# Soymilk


## New processing, packaging expand markets

*One of the fascinating developments in the soybean world in recent years has been the acceptance of soymilk as a soft drink beverage in the Far East. JAOCS assistant news editor Barbara Fitch Haumann prepared the following articles on soymilk to review what's behind the rising sales and how several companies are preparing to increase marketing in the United States. Accompanying the report on soymilk is another report, also by Haumann, on the soyfoods industry in the United States, which also is experiencing a surge in popularity as evidenced by the increasing appearance of such products as tofu in modern supermarkets.*

oymilk, traditionally a Chinese staple produced for many centuries in the home or on the village level, is growing in popularity as a beverage throughout the world. In recent years, large-scale production has evolved, along with commercial marketing of soymilk in Hong Kong, Japan, Taiwan, Thailand, South Korea, Singapore, Malaysia, Switzerland, and now, the United States.

Credited with this transformation are improvements in soymilk flavor to appeal to the tastes of diverse cultures, and aseptic packaging for longer shelf life. Another factor is the marketing of soymilk as a nutritious drink.

It is difficult to determine the amount of soymilk produced and consumed in the world. William Shurtleff and Akiko Aoyagi, in their book *Soymilk Industry and Market* published in 1984 (see accompanying story), admit they can only guess at figures for China, probably the biggest soymilk producer. However, they estimate world soymilk production in 1983 totalled approximately 1 million metric tons made from roughly 130,000 metric tons of soybeans.

A problem in compiling soymilk statistics is pointed out by David Erickson, director of the American Soybean Association's (ASA's) Soy Oil Program Market Development, who says, "There are a lot of street 'hawkers' (in Asia) who go around and sell soymilk. How do you determine figures for that?" There is no question, however, that soymilk consumption has risen substantially in the last six years.

While the largest growth has occurred in Japan and other sections of the Far East, Michael Austin, until August 1984, executive director of the Soyfoods Association of America, believes the U.S. market for soymilk is a promising one. For many years, the U.S. soymilk market has been limited to Asian-Americans, infants and other individuals allergic to cow's milk, vegetarians, and those who for religious beliefs do not consume animal protein. Now, a number of soymilks manufactured in East Asia have been introduced as soft drinks for general appeal. Austin says technology to produce a soymilk geared to American tastes and growing consumer awareness about cholesterol and other health issues is making soymilk a viable product here.

Soymilk, as a staple in the Chinese diet over the centuries, was generally served hot as a breakfast beverage. It also was used to produce coagulated products such as tofu. Today, a substantial amount is still prepared daily for distribution by street vendors in China, Taiwan, Singapore, and Malaysia and used in this way.

The traditional Chinese method for preparing soymilk is to soak the whole soybeans in cold water overnight. The beans then are ground with cold water into a slurry, filtered and cooked. The resulting soymilk characteristically has what is described by Westerners as a beany flavor.

Over the years, soymilk was developed into a food for infants

suffering from malnutrition and for individuals with allergies and diseases associated with diet. In the U.S. and Europe, this type of soymilk was made as a dispersion of soy flour or soy protein isolate in water with various vitamins, minerals, carbohydrates and flavoring added.

According to Shurtleff and Aoyagi, two key figures in the history of soymilk development have been Harry Miller, a Seventh-day Adventist American missionary doctor in China, and K.S. Lo of Hong Kong.

Dr. Miller, cited by Shurtleff as the founder of the modern soymilk renaissance in East Asia, in the 1920s began producing a soymilk for feeding babies, children and nurses in nursing homes and hospitals. In 1936, he and his son Willis opened a soymilk plant in Shanghai, the first of its kind in East Asia. That plant was destroyed in 1937 during the Japanese invasion. Two years later, Miller returned to America and began producing Soya Lac, later renamed Soyalac, a soymilk fortified with vitamins and minerals. He established a soyfoods business in Mount Vernon, Ohio, which he later sold to Loma Linda Foods. Loma Linda Foods currently markets Soyagen for adults and Soyalac infant formulas as soy alternatives to milk.

Meanwhile, K.S. Lo in 1940 founded a Hong Kong soymilk factory and introduced Vitamilk as a milk substitute sold to institutions. After the war, Lo's company reopened as the Hong Kong Soya Bean Products Co. and reintroduced its product, renamed Vitasoy, as a soft drink. "Basically it was the same product although vitamins and some sweetenings had been added," says Vitasoy U.S.A.'s marketing vice president Hilton Tsui.

Later, work conducted by G.C. Mustakas and others at USDA's Northern Regional Research Center (NRRC) and published during the 1970s centered on developing a powdered soy beverage adaptable to the tastes of diverse cultures. The goal was to make a soy beverage with composition and characteristics similar to cow's milk. The first process featured wet milling and spray drying from full-fat soy flour to produce a low-cost, high protein soy beverage powder which then was fortified with vitamins and minerals. Through collaboration with industrial and governmental groups, the beverage powder "Soyacyt," later called "Soyamalt," was developed on a commercial scale in Mexico and also promoted as part of the Mexican National Food Program. A second beverage later developed at NRRC contained less carbohydrate and had better suspension properties. It was also during the 1970s that the U.S. government purchased a corn-soy-nonfat milk product for use in the Agency for International Development (AID) programs.

Meanwhile, efforts were undertaken to improve the flavor of soymilk.

"Eliminating the beany off-flavor is the key in the soy beverage story,"


according to Dr. Lun-Shin Wei of the University of Illinois, one of the important figures in the same story.

The first step came in the 1960s at Cornell University where scientists discovered that soymilk's typical beany flavor and odor were caused by the enzyme lipoxygenase which catalyzed the oxidation of polyunsaturated fatty acids. Cornell researchers W.F. Wilkens, L.R. Mattick and D.B. Hand found they could inactivate the enzyme and produce a fairly bland soymilk by grinding whole soaked soybeans with boiling water or steam to yield a slurry which they then held at 80 C or above for 10 minutes. However, if enzyme activity already had begun, it was too late to eliminate all off-flavors through this method.

Further work in the early 1970s by A.I. Nelson, M.P. Steinberg and Dr. Wei at the University of Illinois showed that the lipoxygenase enzyme present in soybean tissue does not cause off-flavor or odor even when the tissue is broken or crushed unless water is added. Once off-flavor and odor develop, however, they cannot be completely eliminated. The Illinois approach was to blanch soaked soybeans in boiling water for 10 minutes or place dry soybeans directly into boiling water for 30 minutes to achieve hydration and lipoxygenase inactivation at the same time. This process, known as the Illinois method, is touted as "the greatest milestone in soymilk history" by John C. Wilson, soy processes product manager for Alfa-Laval, who sees it as the basis of most modern soybean processing.

"The resultant puree was the finest, cleanest flavored product which could blend with other flavors and take on the flavor of the other with no adverse or objectionable beany flavors destroying the scene," Wilson says.

However, one problem with the product was mouth feel or chalkiness, which Wilson believes has prevented its commercial success.

From this work, processing techniques were developed by large food companies in Japan and Korea during the 1970s. "By 1976, the Japanese were making the best soymilk in the world—by Western standards," Shurtleff writes. Michael Phillips, ASA director of market development, says, "The Japanese have been the leaders in soymilk technology and equipment."

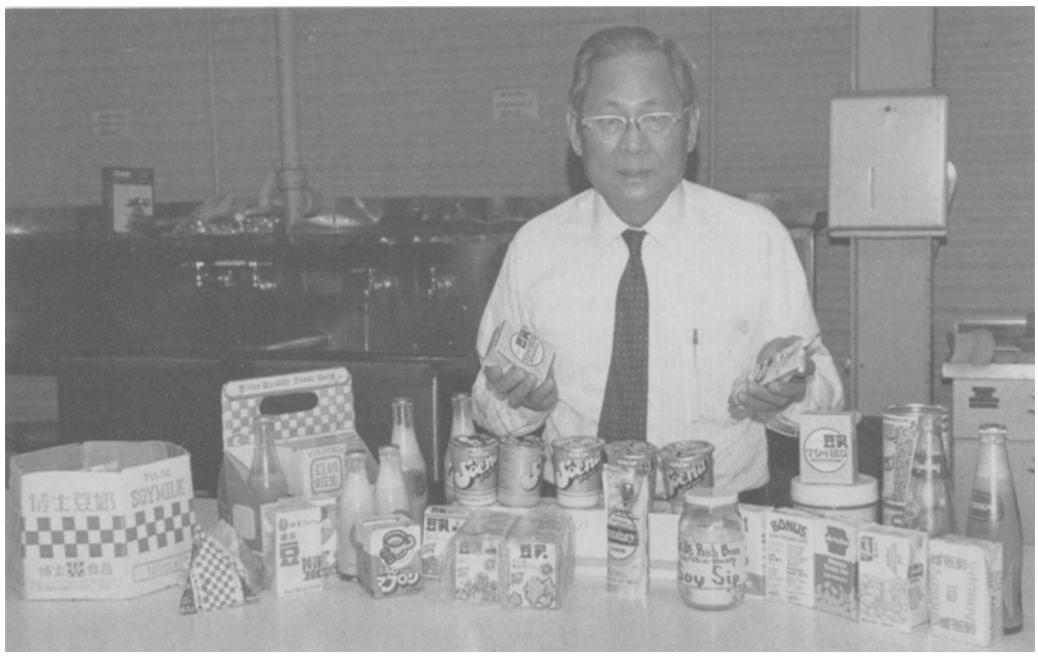
Wilson explains, "Today many processes are available which developed out of the Illinois process but overcame the chalkiness by a filtration step using a decanter or some form of continuous filtration." As a result, soymilk consumption by the early 1980s had skyrocketed throughout East Asia, making it one of the region's fastest growing food products.

Wilson says a drawback of the filtered product is that the protein yield is about half of the almost 100% achieved by the original Illinois method.

"While affluent societies can pay the little extra for such quality, developing countries and especially those without their own crops of soybeans have some difficulty convincing their bankers that the process is economic and feasible," Wilson says.

Erickson says there currently are numerous processes used to make soymilk. Methods include preparing beverages from whole or defatted soybeans or from soy protein isolates.

Soymilk, sometimes referred to as soy beverage or soy drink, can be plain,




**Lun-Shin Wei of the University of Illinois shows off examples of soymilk packaging used over the years, from bottles and cans to tetrahedron-shaped cartons, retort pouches and Tetra Brik Aseptic cartons.**

sweetened, flavored, dairylike, powdered or condensed. It can be sold as a milk substitute, as infant formula or as a healthful soft drink. In traditional filtered or clarified soymilk, the insoluble residue known as okara is removed. Since the 1970s, suspended or whole bean soymilk containing the finely ground or homogenized okara has been available.

Flavors are added to appeal to local tastes or particular age groups. For instance, Vitasoy U.S.A. in 1984 introduced soymilk flavored with maple syrup for the U.S. market because Americans give maple syrup a high rating. Similarly, says Dr. Steve Chen, ASA's country director in Taiwan, flavored soymilk was first offered in Taiwan around 1977 to expand soymilk consumption and to attract younger consumers. However, he adds, adult consumers still preferred the plain soymilk.

Other soymilk flavors include vanilla, chocolate, coffee, strawberry, malt, apple, orange, banana, sesame, yogurt, barley malt, peanut, milk, egg and honey. Secondary soymilk products exist as well. These include soy ice cream, soyyogurt, soy mayonnaise, soy shakes, soy nøg and soy whipped cream.

Alfa-Laval's Wilson points out that soymilk in China still is a primary source of protein, while in Southeast Asia it is perceived more as a thirst quenching beverage.

In Northeast Asia (Japan and South Korea), it is purchased by consumers seeking healthy type foods. In North America, Wilson says, "Tofu and the demand for quality soymilk owe their growth in recent years to the almost fanatic interest and dedication given to these products by groups composed of or influenced by many of yesterday's hippies."

Dr. Chen believes soymilk has great potential as a refreshing drink for nutritional purposes as well as for thirst quenching. "For a successful marketing of soymilk, the soymilk should never be promoted as a nutritious drink just for the poor and hungry people. Soymilk is for everybody and may be consumed at any time," he says.

Lars Wiedermann, ASA's technical director for soy oil in Southeast Asia, based in Singapore, observes that the primary use of soy beverage there is as a snack or soft drink. "Soft drinks, particularly carbonated, are of course popular as people emulate the Western world; however, their popularity in this part of the world lags behind the soymilk/beverage consumption. Soymilk/beverage is a novelty or snack drink which is consumed primarily between meals."

Wiedermann cites Green Spot Bottling Company in Bangkok, Thailand, as an example. "Several years ago Green Spot introduced a bottled soy beverage product as an adjunct to their soft/carbonated drink business. Today their soy beverage sales are larger than their combined soft drink products."

Other potential markets for soymilks are seen in countries where people are lactose intolerant. A 1972 bulletin published by the Protein Advisory Group of the United Nations estimated 50% to 100% of the adults in Africa, Asia, the Middle East and Latin America are lactose intolerant, as are 72% of black North Americans, 6% to 19% of white North Americans and 1% of Europeans.

Dr. Wei acknowledges that in countries where people are accustomed to drinking cow's milk, consumers naturally tend to compare soymilk to cow's milk even though the two are completely different products. Cow's milk flavor is judged on whether it is astringent, bitter, cooked, fermented, fruity, flat, foreign, lacking freshness,

oxidized, rancid, salty or unclean. All of these defects can be found in soymilk including such characteristics as throat-catching, cereal flavor and high viscosity.

Harry Snyder, professor at the University of Arkansas' Department of Food Science, and a student, J.T. Chien, several years ago conducted studies on reducing astringency, or the throat-catching factor, in soymilk. One of their biggest hurdles, Snyder says, was to train the taste-testing panel on measuring astingency. "People's sensitivity to astringency varies," he explains.

According to Shurtleff, soymilk when prepared with the same water content as cow's milk contains 52% more protein, 12% fewer calories, 24% less fat (48% less saturated fat), 16% less carbohydrates and no cholesterol. Compared with mother's milk, soymilk contains 214% more protein, 16% less calories, 19% less fat and 47% less carbohydrates.

Anders Lindner of Soya Technology Systems Ltd., Singapore, says, "It is correct to say that bitter taste and beany flavor can be removed. However, soymilk will never taste just like cow's milk and should be regarded as a product in its own right with its own flavor—which can be described as having a pleasant, cereal-like note."

Refined soy oil may be mixed with soymilk to add calories and whiteness. Lecithin from soy oil adds richness and creaminess. Flavor also can be improved by adding 20% cow's milk or non-fat dry milk powder and soy oil. Vitamins, minerals and amino acids also are added to fortify soymilk.

Alfa-Laval's booklet "Soymilk—Product and Process," points out, "The composition of soymilk is varied within a broad spectrum in accordance with demand and preferences of the different markets where it is sold. For instance, in industrial countries with temperate climate, such as Japan, where soymilk is an alternative to and in competition with cow's milk, it is given the same composition and protein content as cow's milk. In tropical and subtropical countries, on the other hand, soymilk is mostly sold as a thirst-quenching, refreshing drink and is consequently given a much less rich composition, with less protein and fat. Similarly, sugar content and flavoring vary according to consumer taste."

Dr. Chen believes each country should establish quality standards for soymilk to discourage production and sale of a highly diluted product. He says that in Singapore, for example, soymilk must have a protein content of at least 2% weight by volume; with a lower protein content, the beverage must be labeled and marketed as soy drink. In Thailand, meanwhile, soymilk must be fortified with 1% cow's milk in order to be exempt from excise tax.

**Alfa-Laval soymilk lines are among those now available to produce soymilk appealing to Western tastes. (photo courtesy Alfa-Laval)**

In 1981, Japanese Agricultural Standards for soymilk developed by the Japanese Soymilk Association were established. These standards, as outlined by Shurtleff and Aoyagi, include the following: a) plain soymilk contains only soybeans and water, with over 8% soy solids and over 3.5% soy protein; b) dairylike soymilk includes plain soymilk with soy solids content over 4% but under 6%, or plain soymilk with added vegetable oil, sweetening and salt, with soy solids over 6% and soy protein over 2.8%; c) soy beverages—soymilk with soy solids content over 4% but under 6%; soymilk with added vegetable or fruit juices, dairy milk or dairy products, and soymilk with over 5% but under 10% fruit juice added and soy protein content over 1.6%.

While most sources claim the majority of non-Chinese prefer soymilk with some or all of the "beany" flavor removed, Joseph Rakosky Jr., a food industry consultant and soy protein consultant for ASA, says even the Chinese prefer the blander soymilk once they taste it.

Addressing this topic, Shurtleff and Aoyagi write, "Extensive research over several decades by Vitasoy in Hong Kong has shown that Chinese in that city like soymilk best when 60-65% of the beany flavor has been removed and where there is none of the traditional scorched or burned flavor. Be that as it may, Chinese decision-makers seem to strongly prefer soymilk with no beany flavor, perhaps feeling it is a more modern product.

Wilson, meanwhile, notes, "Strangely enough the beany flavor has appealed to several generations now in Southeast Asia, but hardly at all to Northeast Asians and now one may question if, with its full bodied bean aroma, it shall continue to appeal to the young sophisticated affluent Southeast Asians or will they change the demand to the newer innovation."

Already the Chinese are showing interest in the newer soymilk technology. ASA's Phillips reports that one Chinese factory already has purchased the new technology from Marusan of Japan.

The world's largest manufacturers of soymilk for adult consumption are Kibun of Japan, Dr. Chung's Food of Korea, Hong Kong Soya Bean/Vitasoy of Hong Kong, Marusan of Japan, Green Spot of Thailand, Yeo Hiap Seng of Singapore, President Enterprises of Taiwan and Mitsubishi of Japan.

### Japan

In Japan, where the boom began, soymilk consumption grew from 4,000 metric tons (MT) in 1978 to 131,750 MT in 1983, according to Shurtleff and Aoyagi. Dr. Wei explains that large, modern soymilk facilities operate 20 hours or more a day "because they use expensive, high technology equipment."

"Japanese consumers are becoming very health conscious and look for quality foods, preferably vegetable-source, non-cholesterol, alkaline food. Soymilk just meets the requirement of these people," Yoshiko Kojima of ASA's Tokyo office says, noting that soymilk consumption grew 230% in 1982 over 1981. Kojima says approximately 75% of soymilk in Japan is packaged in Tetra Pak aseptic containers, with the remaining 25% packaged in cans, polyethylene bags and coated paper containers.

Soymilk is sold in Japanese grocery stores, supermarkets, health food stores, natural food stores and department stores, mainly in 200 ml packages, with 500 ml and 1,000 ml packages also available. Wilson writes, "Currently quality soymilk holds about 5% of the volume compared to cow's milk. It sells for about 25% over the price of cow's milk." He estimates that the market in Japan totals 100 million U.S. dollars. Dr. Wei, meanwhile, projects that the annual soymilk market in Japan will be worth $170 million in 1984 and grow to $300 million in 1987.

"Japanese marketing initiative will take their success worldwide. It is only a matter of time and calculated risk," Wilson said in June at a Singapore Institute of Food Science and Technology symposium.

### Korea

Dr. Kyung Won Lee, ASA's country director in South Korea, says the soymilk industry currently is expanding rapidly in Korea. "It's in the take-off stage," he says, explaining that as of late 1983, the industry was growing by 60% a year, making it one of Korea's fastest growing industries and one of the world's fastest growing soymilk industries.

Dr. Lee says Korean consumers favor soymilk over cow's milk. "Koreans are very health-concerned people. They prefer vegetable fat to animal fat. The demand for dairy milk is not that strong, plus there is the problem of lactose intolerence in some adults." He said soymilk packages sell for about 25 to 30 U.S. cents, the same price as cow's milk. "It costs less to produce, but Koreans reason how can you claim it is better than dairy milk if you charge less? So they charge the same."

He estimates Korea's seven major soymilk manufacturers produced 67,000 MT of fluid soymilk in 1983. Dr. Chung's Food is the largest company, producing 1 million packages a day, all 180 ml bottles, of its product


Vegemil. The second largest is Dong Bang Oil and Flour Mills, with its Green Milk brand soymilk packaged aseptically. In 1984, Dr. Chung's was constructing a plant to produce 4 million units (180 ml bottles) a day, with capability to handle 120 tons of soybeans daily.

"Soymilk is popular because it meets two objectives, refreshment and nutrition, while other beverages offer only refreshment," Dr. Lee says.

In Japan and Korea, most soymilk manufacturers use one ton of soybeans to produce six tons of soymilk.

### Taiwan

While soymilk is still produced to be sold fresh daily by street hawkers, Dr. Chen says commercial soymilk is sought by more and more consumers in Taiwan because of its convenience, sanitation and nutrition. He reports soymilk is used by hospitals, institution cafeterias and armed forces, and also is sold in grocery stores and supermarkets in Tetra Pak cartons and glass bottles. The price of soymilk here is cheaper than cow's milk.

According to Dr. Chen, one of the most popular flavors in Taiwan is egg "so the soymilk used has to be bland." Wiedermann, meanwhile, says that soymilk and soy beverages are as commonplace in Taiwan as cow's milk is in the U.S.

### Other Countries

Wiedermann adds that while Japan, Korea and Taiwan have seen much of the growth in the soymilk industry, business also is significant in Singapore where there are five primary companies, Malaysia where there are two primary companies, and Thailand with three. "In Indonesia, it is still very small but it has tremendous growth potential, with a population of 150 million without a dairy industry. There are two companies in the Philippines, but it is still a small business compared to others in Southeast Asia." He says ASA has seen much interest expressed in Pakistan, India and Bangladesh but that nothing large has developed. In northern India, however, a small plant that makes a very good product for local distribution is now in operation.

Coca-Cola and others have promoted soymilk in Brazil, while soymilks have been marketed in Mexico and other parts of Latin America. Most efforts, however, have been through subsidized feeding programs. During the 1970s, a new concept, the "mechanical cow," was introduced in Brazil and Mexico. According to Shurtleff, by 1981 there were 90 mechanical cows in Brazil. The "mechanical cow" is a mini soymilk plant that can be operated on a village level.

Rakosky, who serves as a volunteer with the International Executive Corps, spent six weeks in Brazil earlier this year to encourage Brazilians to use more of the soybeans they grow. "Brazil is at the point we in the U.S. were 20 years ago as far as developing markets for soybeans," he says. He adds that Mexicans are trying more soymilk, although skim milk is used extensively. "There is one soymilk preparation in Mexico that is very good. From a simplistic processing standpoint, it's an excellent soymilk." Rakosky said the process uses three boiling steps, with the soybeans first boiled for 5 minutes and the water poured off and fresh water added. The

beans then are soaked 6 to 8 hours, and boiled for 5 more minutes. The resulting soymilk is simmered for an additional 10 minutes. "It's among the top soymilks in the world, in my opinion," Rakosky says, citing the Illinois process, Kibun's process, and one in Egypt using whole soybeans and devised by Loma Linda Foods for the World Food Service, as other good-tasting soymilks.

Alfa-Laval's Wilson, however, calls South America "a market spoilt." He explains, "Take Brazil, the world's second largest soybean producer and exporter. People have had an inferior quality product almost forced down their mouth. Today's fine quality soymilk will have to find a new name and hide its origins before being accepted."

Wilson sees soymilk consumption in Europe developing "slowly but surely," and calls it essentially a health food market, particularly in the United Kingdom. "Europe has not yet been exposed to a product of the same quality as we see on the Japanese market," he says, warning it would be "suicidal" to set up a soymilk industry in Europe as a "substitute cow's milk."

Michael Martin, manager of protein market development at ASA's Brussels office, notes growing interest in soymilk and soyfoods in Europe. Because of this interest, Europe's first soyfoods conference was held in September in Amsterdam. One of the topics discussed was soymilk markets in Western Europe.

According to Martin, the Vandemoortele group in Belgium leads soymilk marketing there. "Overall, the big innovation in Europe currently is making soymilk acceptable to the average consumer." Martin says soymilk products also are being developed in Italy, while tofu burgers have gained 10% of the market share in Paris, instead of an expected 5%.

European companies have played an important role in the developing soymilk industry. The Tetra Pak Group (see accompanying article on soymilk packaging) and Alfa-Laval, both based in Sweden, have been instrumental in modern packaging and processing of soymilk. Other European companies involved in the soymilk industry include Danish Turnkey Dairies of Denmark, which supplies soymilk facilities; Alpro, the protein division of the Vandemoortele group, which was to open the world's largest, most modern soybean plant in Ghent by the end of 1984, and Nestlé, the first European company to market soymilk internationally. In addition, according to Dr. Wei, the Swiss company Galactina Ltd. has been producing soymilk commercially since 1969.

Soymilk also is catching on in other parts of the world. A U.S. Department of Agriculture attache report, for instance, says media report that Egypt, with cooperation from the French, soon will begin producing soymilk for infant feeding in a facility using 10% of Egypt's annual soybean crop.

### ASA's Role

Noting that American soybean farmers have financed research and development of soymilk, Wilson says, "American industrialists have missed the boat in commercializing their native invention." He points to the fact that Americans are now buying back soymilk from Asia which is made with American soybeans: "One day in the future we shall look back and ask the land which provided today's industry with its fathers and its know how, 'What took you so long?'"

Shurtleff, however, disagrees with Wilson's assessment, although he agrees that the U.S. is behind Japan in making as good a quality soymilk.

ASA's Erickson does not rule out that soymilk will catch on in the U.S. but does not foresee that happening immediately. "If and when the soymilk industry and market get big enough in the U.S., ASA will staff for that. In the meantime, we're watching the market."

ASA, however, has taken an active role in soymilk development in other countries. In Taiwan, Chen explains that ASA helped in developing new flavored products and in promoting soymilk through home economics extension agents there. Kojima in Japan, meanwhile, reports that ASA has promoted soymilk jointly with soymilk manufacturers at hotel restaurant shows and national beverage shows. "Since 1956, ASA's Tokyo office has been working with the tofu industry and the Seventh-day Adventists' Dr. H. Miller to promote soymilk by publishing educational leaflets and participating in exhibits," Kojima says. Erickson explains that ASA's role chiefly has been to bring together people interested in investing in soymilk production with those who have developed the technology.

ASA's Phillips points out that soymilk is still a small segment of the overall market, with the largest markets for soybeans in Asia in livestock feed, cooking oils and tofu. USDA figures show 10,000 MT of soybeans used in Japan in 1983 for soymilk, while 470,000 MT went for tofu and 180,000 MT were used to make miso (fermented soybean paste).

"Still, soymilk is good for the soybean image. It helps market soybeans," Phillips says.

### U.S. Market

Convenience and good flavor are two factors Rakosky believes are necessary for soymilk's acceptance, particularly in the U.S. Tom Tommins, president of Tomsun Foods Inc., agrees. "In this country, convenience is a big selling point. Soymilk is convenient, it offers all the good qualities of soybeans and now also offers taste, marketability and distribution ease," Timmins says, predicting there soon will be a lot of competition to market soymilk in the U.S.

According to Michael Austin, executive director of Soyfoods Association of America until August, "Edensoy soy drink marketed by Eden Foods is one of the fastest growing new soyfoods in America right now." He predicts the U.S. soymilk market will develop rapidly in the next several years.

Edensoy, produced by the Marusan Company of Japan, was introduced into the U.S. in July 1983 by Eden Foods, the first Caucasian-American company to import soymilk.

"This product literally put us on the map," says Bena Burda, sales manager for Eden Foods based in Clinton, Michigan. Burda calls Edensoy "the first good-tasting soymilk" marketed on a large scale in the U.S. "It has no aftertaste. It tastes like something you'd care to drink," she says.

Edensoy is made from whole soybeans, pearl barley and barley malt. "It's the lack of other ingredients—oil,

sugar, salt—that makes it different from soymilks such as Vitasoy," according to Eden Foods' purchasing director Ron Roller.

Burda says Eden Foods markets Edensoy as a milk alternative, not as a soft drink. The company sells plain and carob flavors in six-ounce pouches with a guaranteed shelf life of one year without refrigeration. "The plain we market as a substitute for dairy products in cooking and drinking while the carob is marketed as a confectionery drink," Burda says. Roller says the company sells tens of thousands of 30-unit cases a month.

While the company currently imports and sells the product nationwide, Roller said it is pursuing the possibility of a soymilk facility in Michigan. "We feel the future lies in manufacturing the product in this country. We think it definitely will happen," Roller says, explaining Eden Foods is Marusan's agent in the U.S.

San-J International of Colonial Heights, Virginia, is another company to test out the U.S. soymilk market. San-J, a subsidiary of the Japanese soy sauce manufacturer San-Jirushi Corp., earlier this year test-marketed San-J To-Neu, a "natural soy beverage, non-dairy," manufactured by Kibun of Japan. "To-Neu" is a variation of tonyu, the Japanese word for soymilk. Michael Fountain, executive vice president of San-J, says the company was selling the product nationwide through natural and health food stores to see whether it would be economically feasible to produce soymilk domestically.

"There isn't really a market here yet," Fountain says, adding, "Soy has somewhat of a negative connotation in this country. It's going to take some time to change that." Billing Kibun's soymilk as a soy soft drink, Fountain admits, however, the product marketed is a plain flavor "while the market really is in the flavored drink. It seems to be more popular."

Yoshi Aso, in sales management for Kibun Products, Pasadena, California, says, "In Japan, it is a very popular drink because it's seen as a very healthy drink." Aso says Kibun sweetens its soymilk with honey because some consumers see that as more "natural" than sugar.

Vitasoy U.S.A., which already had been the leading importer of soymilk aimed at Asian-Americans, started marketing two aseptically packaged soymilks reformulated for the West in March 1984. According to Hilton Tsui, Vitasoy U.S.A.'s marketing vice president, the reformulated product made by the parent company, Hong Kong Soya Bean Products Co. in Hong Kong, is sweetened with maple syrup and uses all natural ingredients. "We plan to set up local manufacturing, processing and packaging of soymilk in the U.S. during 1985," Tsui says. The company has purchased land south of San Francisco for such a manufacturing facility. When completed, it will make the Hong Kong Soya Bean Processing Co. the first major Asian soymilk manufacturer to start a plant in the West.

"There has been a demand for soymilk all along in the U.S.," Tsui says, explaining, "We're taking it step by step. First we brought in soymilk for the ethnic, oriental market. Now, because people are becoming more nutritionally minded, we think the time is right for our new product. This tastes refreshing and good. People can drink it in place of a soft drink, or juice, coffee or tea." He says the company's primary market is still Hong Kong, but other large markets include the United States, Canada, Australia, Papua, New Guinea and the United Kingdom.

Tsui says that while Vitasoy is sold in bottles and Tetra Pak Aseptic cartons in Hong Kong, it is exported to the U.S. and more than 20 other countries exclusively in Tetra Pak Aseptic cartons.

The Yeo Hap Seng Company of Singapore, meanwhile, produces a vitaminized soft drink, "Vitabean," which it exports to the U.S., Canada, United Kingdom, and Australia.

The Coca-Cola Co., which produces Hi-C soymilk through Swires in Hong Kong for the Hong Kong market, has considered the U.S. market. "However, at the present time we don't see a lucrative soymilk market in the U.S. The healthfood industry is the only viable U.S. market right now," according to Dr. George Hunter, manager of applied flavor research and quality control, Corporate R&D Department, The Coca-Cola Co., Atlanta, Georgia, who with other colleagues developed the company's soymilk for the Far East.

Dr. Hunter says the company's current products are plain and malt, placed on the market first in June 1982 in Hong Kong. "We see further potential markets in the Far East, however," he adds.

Other Japanese soymilks on the U.S. market include Ah Soy, imported by Great Eastern Sun Company of North Caroline, and Westsoy, imported by Westbrae Natural Foods of California.

"We see more soymilk products as expanding the market, rather than as competition," Eden Foods' Roller says.

Likewise, smaller U.S. companies which produce soymilk as a fresh product chiefly for the health food industry do not necessarily feel threatened by the new high technology products being imported from East Asia. Robert Werz, president of Appropriate Foods Inc. of Franklin Square, New York, whose company sells 100 gallons of fresh soymilk a week to 80 health food stores and natural food restaurants in the metropolitan New York area, explains, "The new high-tech soymilks imported are good for the soymilk market in general. They will put more money into marketing of soymilk and make more people aware of it." Health food "purists," he believes, will still want to buy the fresh soymilk made from organically-grown soybeans.

Rakosky sees a number of obstacles to soymilk's successful marketing in the U.S. "One is it's seen as an imitation milk, as it isn't cow's milk. A second is it creates a battle of dairy versus soy industries. Others don't like the name 'milk.' An advantage, however, is you can tailor-make soymilk to the market you're targeting." The best marketing technique, he says, is to sell a good-tasting soymilk and stress "that it's good for you."

Judi Trujillo of ASA's Soy Oil Market Development Program believes, "In this country it would be better to market it as a soy beverage. If you try to market it as soymilk, it can cause problems with the dairy industry."

Shurtleff and Aoyagi report soymilk labeling conflicts have arisen already. In their *Soymilk Industry & Market* report, they write, "The term 'milk' can only be used legally to refer to the 'lacteal secretion of the

mammary gland, practically free of colostrum, obtained by complete milking of healthy animals.' However, a broader principle states that a food may be called by its own 'common or usual name.' Powerful state dairy boards worked actively to have the former principle applied. The soymilk industry felt that the latter should apply . . . only expensive court battles (in each state) will be able to resolve the dispute."

For that reason, they point out, most U.S. soymilks are labeled with fanciful names, such as Soy Fresh, Vitasoy, Soy Moo, Soy-Yai, Nutrosoyo. They add, however, that state agencies do allow the term soymilk on labels if the phrase "Contains No Dairy Products" also is prominently displayed.

In Canada, meanwhile, the term "soymilk" was legalized in April 1984, Shurtleff reports.

Nelson, of the University of Illinois, does not believe soymilk has the marketing potential in the U.S. that it might have in other countries because of the large dairy industry. "Certainly there's more chance for change in other countries traditionally lacking dairy products. In places where people prefer a vegetable source of protein, there is much more potential for soymilk than for promoting cow's milk."

Admitting, "I was very optimistic at one time about soymilk," the University of Arkansas' Snyder adds, "It hasn't caught on as I thought it might. Perhaps it could with the right flavor and the right price." He believes that in the U.S., soymilk will have to be produced near the market in order to keep the price low enough. "Imports are going to cost too much,"he says, adding, "I'm sure some industries will be interested in using soymilk in place of cow's milk in such products as soups if they can be guaranteed the quantities they want."

Dr. Chen agrees. Noting that most food items using dry milk powder may be replaced by powdered soymilk, he sees great market potential for low cost powdered soymilk with bakeries, ice cream makers and confectioners, for example.

Meanwhile, researchers such as Dr. Wei continue to study soymilk. Dr. Wei and his students at the University of Illinois, for instance, are studying what controls the viscosity of soymilk. In addition, Dr. Wei has developed a method for producing sweet condensed soymilk which he hopes will be marketed commercially one day.

In other research, USDA in 1983 announced that a group from the Agricultural Department of Iwate University in Japan had developed a soybean cultivar devoid of lipoxygenase. USDA officials pointed out that if ever produced commercially, the new soybean could eliminate some of the costly processing now needed to produce a soymilk without off-flavors.

Soy promoters agree that currently the technology exists for producing good-tasting soymilks appealing to diverse cultures. The question remaining is how long it will take before soymilk will become a common beverage throughout the world. Alfa-Laval's Wilson believes it eventually will happen. Wilson in June told the Singapore Institute of Food Science and Technology, "The world has only seen the beginning. The 'big event' in our industry is yet to happen. 'When?' you ask. When banks trust. When industry risks. Technology is ready."

Feature

# Soymilk processing

## How manufacturers try to reach Western market

"To produce a 'bean free' tasting soymilk, nothing is so successful as prevention," according to John Wilson of Alfa-Laval. With that theory in mind, processes and equipment have been developed to commercially produce soymilk appealing to Western tastes.

Among the companies providing soymilk turnkey services are STS-Soya Technology Systems Ltd. of Singapore, a member of the Danish Turnkey Dairies Group of Denmark; and Alfa-Laval of Sweden, which cooperates internationally with Kibun of Japan on soymilk projects.

Wilson says the beany taste can be prevented by roasting or toasting the soybeans prior to grinding; using radiation; or blanching by steam, hot water or hot sodium bicarbonate. Dr. Steve Chen, ASA country director in Taiwan, meanwhile, cites seven methods to eliminate off flavors. They are: hot water grind (Cornell method); blanching (Illinois method); vacuum deodorizing; resuspending soy isolate or soy concentrate; enzyme fermentation using *Lactobacillus acidophilus* or certain molds to mask the beany flavor; alkaline soaking, and open cooking to transform beany flavor into a nutty flavor.

Alfa-Laval's process, as outlined by Wilson, begins by cleaning whole fresh soybeans without using water. Beans and water then are fed continuously and simultaneously into a grinder and hermetically ground under controlled temperature. Remaining steps include separating the okara (soy pulp); inactivating the enzymes and trypsin inhibitors in a steam infusion system; deodorizing in a vacuum condensor and deaerating; blending ingredients such as sugar, vegetable fat, emulsifiers, stabilizers and flavorings; deaerating again, followed by ultra high temperature (UHT) treatment and aseptic packaging. UHT treatment, consisting of heating the soymilk to 140 C for several seconds prior to aseptic packaging, extends the product's shelf life; it is a process pioneered by Alva-Laval.

Alfa-Laval's main process lines produce clarified low bean flavor soymilk and suspended low bean flavor soymilk.

STS-Soya Technology Systems, meanwhile, offers processing lines for producing non-beany tasting soymilk with capacities from 350 to 15,000 liters, depending on the desired protein content. Company literature says the 2,000 liter capacity per hour, for instance, "is based on finished soymilk with 3.5% protein content."

According to Anders Lindner of Soya Technology Systems Ltd., the STS process combines various methods and is designed to use commercial soybeans; inactivate oxidizing enzymes which cause beany or bitter taste; inactivate soybean trypsin inhibitor; remove oligosaccharides; produce a soymilk with a pleasant, universally acceptable taste and mouthfeel; maintain high nutrition value, and achieve a high yield.

Advertisements for Soya Technology Systems promote the company's "Golden Bean" process formula to remove the bean taste. The company claims; "The STS process formula has a fully adjustable viscosity/protein content to adapt the product ranging from a 'food-strategy' for a hungry nation to a flavored 'fun beverage.'"

Lindner says STS currently is building facilities in Europe and Asia, and has projects "in the pipeline" for both Africa and the Americas.

According to Shurtleff and Aoyagi, by 1984 all Japanese soymilk manufacturers were using a process based on the Cornell University discovery that heat inactivates lipoxygenase enzymes and similar to the Illinois method devised by Nelson, Steinberg and Wei but "with a filtration step in the middle." They outline the following steps in the Marusan soymilk process of Japan: dehulling to improve taste and shorten heating time; enzyme inactivating through boiling water or steam; grinding, typically with very hot water; filtering to separate insoluble fiber from the soymilk; deaerating to defoam the soybeans; homogenizing, with oil or sweeteners added; super heating to cook and pasteurize the soymilk; vacuum deodorizing to strip off flavors from the soymilk; homogenizing; cooking and cold storage in aseptic tanks; packaging in retort pouches or Tetra Brik Aseptic cartons, and cold holding and storage. Some Japanese companies, they add, refrigerate their soymilk for four days after packaging to produce a milder flavor.

A number of factors can affect the resulting protein content of soymilk. First is the water-to-bean ratio used in extraction. According to Dr. Chen, commercial operations generally use a 10:1 ratio of water to beans, with one kilogram of dry soybeans yielding approximately 40 cups of soymilk of 2.7%-3.3% protein, 6% solids and 1.2%-1.6% fat. Other factors include the temperature for extraction and grinding, time and temperature for cooking, protein content and variety of soybean used, number of times and at what temperature the residue is washed, how dry the residue is pressed, how fine the soybeans are ground, and the condition and time the soybeans are stored.

The shelf life of soymilk depends on the way it is processed and packaged. Pasteurization, UHT treatment and sterilization are used to prolong shelf life. Pasteurized soymilk can be packaged in paper or plastic cartons, plastic pouches, or glass or plastic bottles. Such soymilk has a shelf life of approximately seven days and must be refrigerated. UHT treated soymilk, meanwhile, should be aseptically packed. The most widely used system is the aseptic system made by the Tetra Pak Group. Shelf life is approximately six months without refrigeration. Sterilized soymilk can be packaged in glass bottles, cans or aseptically in presterilized containers (see accompanying article).

Feature

# Soymilk packaging

## Aseptic packaging spurs increased sales

Soymilk, still consumed fresh in many parts of the world, is increasingly appearing in high technology aseptic packaging. In 1983, approximately 75% of the soymilk sold in Japan was packaged in aseptic containers. Meanwhile, long-life Brik Aseptic packages containing soymilks were introduced into the United States in 1983.

Aseptic packaging is a rapidly developing technology. According to *Food Processing*, more than 100 machines to handle fruit juices, drinks and other foods have been installed in the U.S. in the past two years. This type of packaging has been commonplace for two decades in many countries. However, it was not until the Food and Drug Administration in January 1981 issued a regulation allowing the use of hydrogen peroxide and heat as a package sterilant that the U.S. opened the door to this technology.

Aseptic packaging appeals to manufacturers for a number of reasons. The lighter weight packages reduce freight costs, and the cube or brick shape can be stacked easily on supermarket shelves. The cost of the container is less than metal or glass, although converting packaging lines to handle aseptic technology can be costly. U.S. companies that have tried aseptic packaging have received favorable consumer acceptance, perhaps because of convenience. According to *Food Institute Report,* aseptic packaging in the U.S. is projected to eventually take over one-third of fruit juice packaging and as much as 45% of milk sales.

"People are getting accustomed to drinking soft drinks and fruits from these type packages. It is logical they would accept soymilk in them," Judi Trujillo, ASA's associate director of soy oil program market development, says, pointing out another advantage. "Soymilk in bottles can look awful. Tetra Brik Aseptic cartons have been a big step for soymilk because you don't have to see the product."

A November 1983 *Food Flavorings, Ingredients, Processing and Packaging* article explains that the types of packaging that can be used aseptically include boxes, tetrahedron shaped cartons, bag-in-box, plastic tubes and pipettes, plastic cups or tubs, wide-necked bottles and stand-up bags. Most, it says, have multi-layered foils or polylayered plastic.

According to John Wilson of Alfa-Laval and authors William Shurtleff and Akiko Aoyagi, soymilk during the 1940s and early 1950s was sold like milk, in bottles sealed with a paper cap. In the 1950s, K.S. Lo of Hong Kong Soya Bean Products Co. of Hong Kong and Yeo Hiap Seng in Singapore began selling soymilk in soft drink type


bottles closed with a metal crown cap and sterilized for longer shelf life. In 1967, soymilk appeared in ultra high temperature (UHT) aseptic Tetra Pak tetrahedron shaped cartons requiring no refrigeration. Yeo Hiap Seng was the first company to sell soymilk in these containers. "The shape didn't work well, as it was difficult to box them together or stock them on shelves," according to Dr. Lun-Shin Wei, who admits they were an improvement over bottles which were difficult to clean for reuse.

Wilson says the advent in 1969 of the brick shaped Tetra Brik Aseptic carton was a milestone for soymilk's commercialization: "The effects were immediate, lasting and are continuing." In 1976, Hong Kong Soya Bean Products Co. began exporting products in Tetra Brik Aseptic packages.

Since the late 1970s, aseptic containers have dominated soymilk packaging. Other packaging forms used include glass and plastic bottles, cans, stand-up retort pouches and Pure Pak cartons. The primary manufacturer of aseptic packaging for soymilk has been The Tetra Pak Group (known as Brik Pak Inc. in the U.S.). Tetra Pak's main competitor for aseptic packaging is the Jagenberg Co. of West Germany, with its Combibloc Aseptic system.

According to Dr. Wei, at least 500 million Tetra Brik Aseptic packages of soymilk were sold throughout the world in 1983. In Japan, most are packaged in 200 or 250 ml size packages. Dr. Wei says aseptic packaging in 1983 included approximately 80 million packages in Taiwan, 55 million packages in Hong Kong, 45 million packages in Malaysia and 38 million packages in Korea.

Shurtleff says, however, "There is a growing consensus that much of Japan's future soymilk will be sold in Pure Pak which cost about half as much as Tetra Brik Aseptic cartons and have a shelf life of seven days." Tetra Brik Aseptic cartons provide up to six months' shelf life without refrigeration.

Wilson, meanwhile, says new low cost aseptic packaging is available for developing countries. "The shorter shelf life is an acceptable limitation in such markets." Wilson adds that oxidation prevention in aseptically packaged cartons remains a problem when the product is a high protein, high fat milk-like drink.

According to Dr. Wei, packaging dates in Japan indicate when the product has been put on the market and when it should be removed. However, with refrigeration, aseptically packaged soymilk may remain good for many months beyond that. In Southeast Asia, the products are not refrigerated but are stored on open shelves. "If you can't pour it, you know the soymilk has spoiled," Dr. Wei says.

Feature

# Soymilk worldwide

## Shurtleff, Aoyagi chronicle soymilk industry

"The dramatic growth of the world soymilk market since 1978 is one of the great soyfoods success stories of all time," William Shurtleff and Akiko Aoyagi write in The Soyfoods Center publication *Soymilk Industry & Market: Worldwide Country-by-Country Analysis,* published in 1984.

They explain, "In Japan, for example, soymilk production has been growing at the astonishing compound rate of 101% a year since 1978, and every major Japanese dairy company now makes and sells soymilk. Throughout East Asia the industry has been growing at roughly 50% a year since the late 1970s. And interest has been growing in the West as well, where soymilk imports rose by about 60% during 1983."

Their report, which studies chiefly the adult soymilk industry and market, points out that the average Chinese consumes at least 500 ml a year, for an annual total of 500 million liters. For countries where statistics can be estimated, the report ranks Taiwan first, with annual per capita soymilk consumption of 11.1 liters based on 210 million liters produced in 1983. Japan, the report says, produced 131.8 million liters, with per capita consumption of 1.1 liters. Other countries included were Hong Kong, producing 39.1 million liters; South Korea, producing 67 million liters; Malaysia, producing 21.4 million liters; and Thailand, producing 50 million liters. These figures, Shurtleff points out, are for adult soymilk produced from whole soybeans and do not include soy-based infant formulas, usually made from soy protein isolates.

Shurtleff and Aoyagi estimate world soymilk production to total 1,065 million liters, or about 1 million metric tons (MT), requiring roughly 130,000 MT of soybeans. Their directory lists 166 known soymilk manufacturers, 30 of which are in the U.S. It does not include small shops in China and East Asia.

"Soymilk has shown the most rapid growth in countries and regions which have not traditionally consumed much animal milk," they write, adding, "Although people in East Asia have traditionally consumed relatively little cow's milk, in only a few (Taiwan and perhaps China) does consumption of soymilk exceed that of cow's milk. In Japan in 1983 soymilk consumption was a mere 3% of cow's milk consumption.

Shurtleff and Aoyagi explain that in Japan, large dairy milk companies recently have realized that soymilk and cow's milk are complementary, rather than competing, products and that soymilk would expand their market size to reach people who ordinarily don't drink cow's milk.

"In our opinion, Japanese soymilk is the world leader in terms of good flavor, color, texture/mouth feel, and aroma," they write, adding that since 1980, soymilk has been marketed in Japan primarily on the basis of good health and nutrition.

Shurtleff and Aoyagi note that while soymilk had been an important part of the Chinese diet for centuries, it was not until the late 1970s that the image of soymilk was upgraded there from a traditional poor quality product to a modern, economical and nutritious beverage.

"By 1983, soymilk was one of the 'hottest' food subjects in China," they write. "The future of soymilk in China looks promising, especially if the Chinese can find ways to develop sustained and mutually satisfactory business relationships and technology transfer programs with foreign companies and soymilk professionals."

On the world scene, Shurtleff and Aoyagi predict "retail (soymilk) soft drinks will probably lead the way, with subsidized use in school and infant feeding programs running a close second. Bulk sales to the food industry (as for use in baked goods or in fast food establishments in place of milk) also hold great promise, with many opportunities for innovation as a dairy extender or analog.

"Geographically, the greatest immediate growth potential seems to lie in Third World countries, where sources of taste, low-cost protein and energy are in greatest demand," they say, mentioning China, Brazil, Mexico, Argentina and Nigeria as among the largest potential markets. However, they believe it will take longer for soymilk to catch on in the West. The main obstacles cited are 1) cow's milk, widely available at low prices, is traditionally popular and has a good image nutritionally; 2) no good-flavored soymilks are yet produced in the West; 3) all soymilks in the West are more expensive than cow's milk; 4) laws prevent the use of the word "soymilk," and 5) the dairy industry sees soymilk as a threat.

Shurtleff and Aoyagi also foresee a soymilk glut in the U.S.

"During 1984 and 1985 a small tidal wave of imported and domestically manufactured soymilk will wash across America. It could flood the market. Companies with plants in America may be forced to cut prices to keep their plants running, leading to a price war, where everyone loses money. This, we feel, is a greater concern than problems of how to market soymilk to America." A possible solution, they

say, would be for domestic soymilk manufacturers to broaden their product lines to include secondary soymilk products such as soy ice cream or soy yogurt.

[In their book *Soyfoods Industry & Market: Directory and Databook 1984-85,* also available from The Soyfoods Center, Shurtleff and Aoyagi predict that in the next few years, one or more of America's larger food processing companies will start making and marketing tofu and second generation tofu products. "They will probably start their own plant rather than buying an existing company. There is a good chance that a large Asian tofu or soymilk manufacturer will build a plant in America to make both tofu and soymilk."]

Shurtleff and Aoyagi divide the U.S. adult soymilk market into five segments: Asian-Americans (34%); natural foods (26%), Seventh-Day Adventists (23%), health foods (12%), and mainstream Americans (5%). They say 92.3% of all soymilk consumed in the U.S. is made from isolated soy protein and used for infant formula, while 5% is soymilk for adults made by large American food companies. In addition, 2% is imported from East Asia where it is made from whole soybeans, mostly grown in the U.S., for adult consumption. The remaining 0.7% is soymilk made by domestic tofu companies as a sideline.

Imported soymilk, they say, is the fastest growing segment of the market. Primary importers include Vitasoy U.S.A. Inc., Yeo's (Yeo Hiap Seng), Eden Foods, Kibun, President, San-J International and Vandemoortele.

The report says that in order to be marketed successfully, soymilk must have a good taste, be offered at a price competitive with cow's milk and soft drinks, and be perceived as offering definite health benefits.

Heavily flavored soymilks, such as carob flavored, get the highest ratings from Americans in general and consequently have more chance of success than plain or dairylike soymilks.

*Soymilk Industry & Market: Worldwide Country-by-Country Analysis* can be obtained from The Soyfoods Center, PO Box 234, Lafayette, CA 94549. The 177-page report plus 100-page spiral-bound photocopies of soymilk labels, posters and other graphics are available for $350 for the first copy and $250 for each additional copy. The 203-page *Soyfoods Industry & Market: Directory and Databook* costs $95 plus postage.

# Soyfoods entering mainstream U.S. diet

Once relegated to small "natural foods" outlets, soyfoods now can be found in major supermarket chains throughout the United States, in specialty departments of large food stores and in virtually all of America's 6,000 "natural foods" stores.

"Soyfoods are entering the mainstream of American diets," according to Michael Austin, until August 1984 executive director of the Soyfoods Association of America. Austin cites the interest of supermarkets in carrying a variety of soyfoods in their showcases, the now common appearance of tofu cakes in supermarkets, and the publication of 41 tofu cookbooks since 1975 as signs of soyfoods' growing popularity.

In general, Austin believes, the soyfoods industry is on the brink of phenomenal growth in the U.S.

"One of the indicators is Midwest newspapers and farm magazines are picking up the story of soyfood," Austin says, mentioning, for example, that an Ohio farm publication included an article on tofu cooking. "When folks raising soybeans in the Midwest start to eat tofu, I see that as very encouraging." Austin says soyfood consumption in the U.S. began as a health food movement, "a vegetarian or New Age way of 'right living' to eat high protein at low cost. Now, however, I see acceptance by a more conservative segment of the American population."

Lun-Shin Wei and A. I. Nelson of the University of Illinois say oriental soyfoods currently are a $400 million industry in the U.S., although not all of the products are manufactured domestically.

A variety of foods derived from soybeans is available, from appetizers, entrees and side dishes to ice cream-like desserts. The five primary traditional soyfoods are soy sauce, soymilk, tofu, tempeh and miso. The Soyfoods Center, Lafayette, California, offers the following definitions for some of these foods:

- Soy sauce—a generic term for a variety of types, which can be fermented (made by natural fermentation using enzymes from *Aspergillus oryzae*) or chemical (made within a day with hydrolyzed vegetable protein, hydrolyzed with hydrochloric acid) and containing corn syrup, caramel coloring, salt and water.
- Tofu—the pressed curds of coagulated soymilk sold in the form of a wet, cream-white colored cake.
- Tempeh—foods made by fermenting soybeans and/or grains with a *Rhizopus* mold until they are bound together into a compact, fragrant cake;

often used by vegetarians as an alternative to hamburger.

- Miso—a fermented seasoning paste made with soybeans and usually rice or barley.
- Yuba—the film that forms on top of soymilk when it is heated for approximately seven minutes at 80-90 C.

Other soy-derived foods usually incorporated into other products include defatted soy flour, flakes and grits; soy protein concentrate made from defatted soy flour; soy protein isolate; textured soy protein products, and meat analogs.

Soy sauce is the the largest selling soyfood product in the U.S. According to William Shurtleff and Akiko Aoyagi, soy sauce sales are larger than those of all the other soyfoods combined. Soy sauce production is estimated to total 13 million gallons annually, worth over $200 million.

Ron Roller, purchasing director for Eden Foods of Clinton, Michigan, says soy sauce and miso have gained in popularity in the past three years. "The new low sodium soy sauces, for instance, are being substituted for salt." Roller adds that miso, particularly instant miso soup, is becoming a popular convenience food.

Tofu, meanwhile, has become the industry's 'premier product,' according to Austin. "People want to learn how to prepare it, make it more palatable." However, he predicts, improved technology which is producing soymilks appealing to American tastes will soon make soymilk a leading soyfood product in the U.S.

According to Soyfoods Association figures researched by Shurtleff and Aoyagi, the U.S. soyfoods industry in 1983 included approximately 270 companies, of which 182 companies produced 27,500 tons of tofu valued at $55 million in retail sales, more than double the 13,250 tons worth $23.2 million produced by 120 companies in 1979. Production of fermented soybean patties, called tempeh, meanwhile, had reached 460 tons annually, worth $1.7 million and marketed by 25 companies. In this category, ready-to-eat tempeh burgers were a fast selling item. Also, the fermented spread miso was valued at $8.2 million in sales for both imported and domestic brands.

The momentum in growth for the soyfood industry has been a very recent phenomenon. Setting the foundation were a group called the Soycrafters of North America (SANA), formed in 1978, and William Shurtleff who, with his wife, Akiko Aoyagi, founded The Soyfoods Center in 1976. Shurtleff and Richard Leviton, SANA director from 1979 to 1983 and recent editor of *Soyfoods* Magazine which he founded five years ago, can be credited in large part for their work to promote soyfoods as healthy food for American consumption. The Soycrafters, of which both Leviton and Shurtleff were members, helped provide technical assistance and information for launching new businesses in the industry. From the Soycrafters evolved the current Soyfoods Association, a trade association which formally formed in 1983 to help market soyfoods on a larger scale. As of mid-September 1984, the Soyfoods Association had grown to 63 members.

Shurtleff's The Soyfoods Center continues to serve as an information center about soyfoods, particularly tofu, soymilk, tempeh and miso. His belief is that soybeans should be a key protein source for the world for the future, with both traditional and modern soyfoods from the East and West included in human diets.

While the soyfoods movement originally was seen as a countercultural step by those opposed to using soybeans to feed livestock to produce animal protein and in favor of ending world hunger by feeding people soy protein and soyfoods directly, it has become a maturing industry featuring larger companies using high technology, national distribution and packaging and marketing innovations.

In an article in the November 1983 *FDA Consumer,* Harold Hopkins noted, "The future of the soybean as food for Americans is closely related to how well soy proteins are integrated into existing foods, or used to replace such foods, without sacrificing the color, flavor, texture, odor, eating quality, nutrition and chemical characteristics of our traditional foods. Overcoming or masking the beany taste is one of the biggest hindrances to better acceptance of soybeans in the marketplace."

Shurtleff and others in the industry see the importance of emphasizing the role of soy protein foods as foods in their own right, rather than as ingredients to be disguised in other foods. For instance, Shurtleff points out that since 1979, there really hasn't been substantial growth in the soybean protein isolate concentrate market although the soyfoods market itself has grown at least 15 to 20% each year.

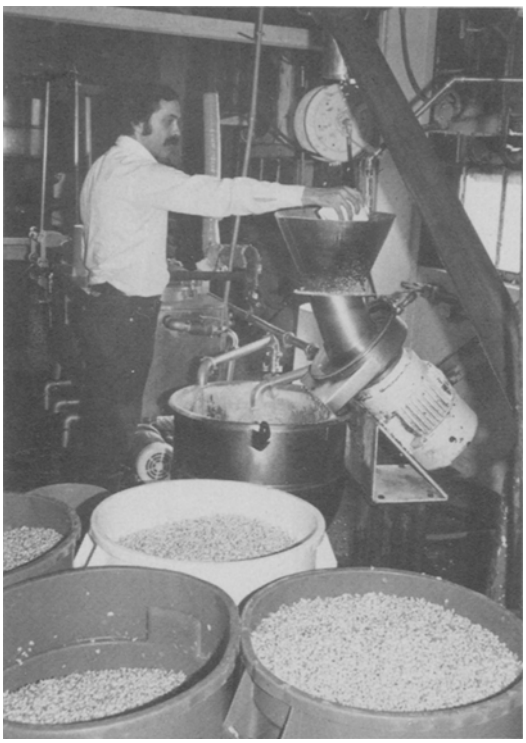
Still, soyfoods make up only a small portion of the U.S. soybean market. According to USDA's Northern Regional Research Center, more than half of the soybeans and soy products produced in the United States currently are exported. Soy meal fed in the U.S. in 1981 accounted for 88% of the total oilseed meal, 71% of the high-protein feed, and 48% of all processed feed used. Of the U.S. soy protein available, less than 5% goes into human foods, such as meat extenders, simulated meat, baked goods, dairy analogs, dietary food, infant food and fermented food products. Less than 1% of U.S. soy protein is used in industrial products. Meanwhile, up to 95% of U.S. soy oil is used in food while 5% goes into a variety of industrial products.

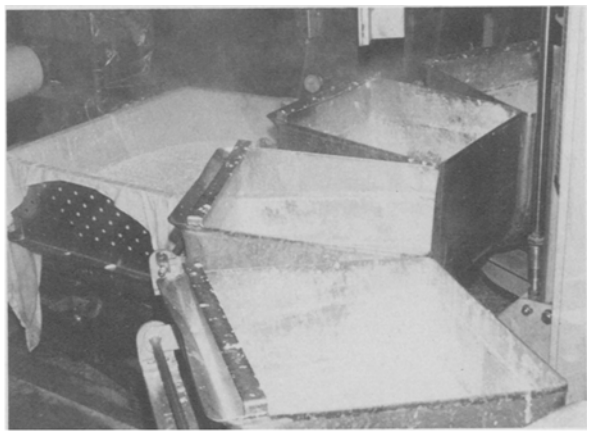
And that, American Soybean Association officials explain, is why ASA has not taken a big role in promoting soyfoods domestically.

"Ever since the 1960s, this industry has been 'just around the corner.' We're still waiting," David R. Erickson, director of ASA's Soy Oil Program Market Development, says, adding, "It's still too small a market. Soy protein is less than 5% of the total soy meal usage."

Conceding that The Soyfoods Center helps fill a void for the industry, Erickson says ASA and the center differ philosophically; Shurtleff is among those who believe it is wrong to feed animals soybeans to produce meat while protein shortages exist, and ASA represents soybean farmers who sell 95% of their soy meal to the animal feed industry. Shurtleff agrees, but adds that he believes ASA has a conflict of interest over developing soyfoods in the U.S. and working with the meat and dairy industries, large consumers of soy protein for animal feed.

Erickson says ASA has effectively





Soybeans first are soaked, ground into a slurry and cooked to make soymilk (upper left). A coagulant then is added, and the resulting curds pressed to form tofu (upper right).

A worker at Tomsun Foods cuts the tofu into blocks (lower right).

Tofu blocks are placed into packages, then pasteurized and chilled to approximately 45 F (lower left).

promoted the use of soy oil domestically and has actively encouraged soyfood usage abroad, however. For instance, a significant portion of soybeans exported by the U.S. to Japan goes into producing soyfoods. "ASA hasn't done this promotion at home mainly because we don't perceive a domestic market for it. Soyfoods are a good way of providing nutrition, but it still comes down to the question of where you want to invest your money. We don't see soyfoods as that attractive economically. Soyfoods in general just have not taken off yet in the U.S."

Marketing strategies currently being used center on the nutritional aspects of soyfoods. Manufacturers tout their products as high in protein, low in calories, cholesterol free and low in salt. Such an approach is seemingly successful, playing to Americans' growing concern over health and fitness. With recent publicity over cholesterol's possible link with heart disease, American consumers are seeking healthy and inexpensive foods low in fats and calories.

A promotion by one company, for instance, claims, "Soybean fats are unsaturated and contain almost no cholesterol. The linoleic acid found in the fats plays a large role in preventing the accumulation of cholesterol. Soybeans are also rich in vitamins and minerals."

Promoters of tofu, meanwhile, point out that their product is an inexpensive source of good quality usable protein, that it is cholesterol free, low in saturated fat and salt, and high in potassium, iron, calcium and other minerals and vitamins. Tofu, they say, can easily be adapted for use in many recipes and is easy to digest without the flatulence-producing effects of soybeans.

An article in the December 1983

*Journal of Nutrition Education* which focussed on "Nutritionally Economic Foods," gave tofu a high rating. The ratings were determined by dividing the number of calories by the nutrients present at greater than 50% of the U.S. RDAs in the amount of food purchased for one dollar. Meanwhile, the January 1984 issue of the *Journal of the American Dietetic Association* reviewed nutrients in vegetarian foods, including soybeans, soy sprouts, soy flour, miso, soymilk and tofu.

Dr. Wei and Nelson of the University of Illinois' Food Science Department point out that currently, no protein can be produced in such mass quantities or as economically as soybeans. "At present and into the foreseeable future the soybean offers the most workable answer for the world shortage of protein," they write.

However, Dr. Wei and Nelson do not favor promoting the use of vegetable protein at the expense of animal protein. "Presently societies which use animal protein will and should continue to do so. In the future, it appears that all sources of protein will be needed to satisfy the increasing demand. However, animal protein will be used by certain cultures as long as the people can obtain and afford to pay the price for meat. As time moves on, both animal and vegetable protein will be in much greater demand."

Because whole soybeans can produce very bland flavored products, soy can be blended into traditional foods to improve the protein content without altering their flavor or acceptability. This is important, Dr. Wei is quick to emphasize, for unless people actually consume the food, nothing is accomplished by fortifying it with soy.

"It must be remembered that food has no nutritional value until it is eaten," Dr. Wei and Nelson wrote in a paper about the International Soybean Program (INTSOY), based at the University of Illinois, and the use of whole soybeans. They added, "Simply serving excellent soy foods to local people will have little or no effect as regards their continuing interest in using the nutritious foods." Consequently, teaching consumers how to incorporate such foods in their diet by holding cooking classes and distributing recipes is important.

Soyfoods manufacturers have adopted such marketing strategies as well as national campaigns offering promotional coupons to help spread the soyfood message. Special delicatessens and shops selling soy products—soy sprouts, soy nuts, tofu burgers, frozen tofu lasagna and pizza, tempeh patés, tofu dips, tofu cheesecakes, tempeh enchiladas and frozen soy desserts—have also helped cultivate soyfoods' popularity.

According to Austin, a soy drink called Edensoy marketed by Eden Foods "is the hottest selling soyfood product right now." Austin believes this is one indication that the U.S. soymilk market will boom in the next several years.

Other popular products include frozen desserts designed as alternatives to dairy ice cream. Such frozen desserts can be soft serve, dispensed out of machines, or hard packs, sold in supermarket frozen food sections. Perhaps one of the best known is Tofutti, manufactured by Tofu Time in Brooklyn, New York, and distributed in various parts of the country. Tofutti is sold at the Concourse at the World Trade Center, in stylish restaurants such as Bloomingdale's 40 Carrots, and in upscale gourmet shops such as Faye Allen in New York City.

David Mintz, president and chairman of the board of Tofu Time, says, "There's a real momentum building up for soy-related products. There's no question in my mind that the new food of the 1980s is soy products. They are gaining rapid acceptance."

Mintz credits consumer acceptance of products such as Tofutti to a number of factors: a perception that it is a healthy food; it tastes good; it doesn't leave a heavy bloated feeling after eating it; people with lactose intolerance can eat it ("It's like being born all over again to be able to have desserts," Mintz explains); and perhaps the biggest reason is "it's cholesterol free. All the publicity over cholesterol makes tofu and soy products so timely."

Mintz points out that Tofutti is a polyunsaturated frozen dessert with a polyunsaturated to saturated fat ratio of three to four, "which makes this product exceptional."

National distribution for soyfoods is still evolving. California, particularly the Los Angeles-San Francisco area, is seen as the soyfood "hub." Other primary soyfood markets include the East Coast, from Boston to Washington, D.C.; the Pacific Northwest; the Northern Midwest, including such cities as Chicago, Minneapolis, Madison and Milwaukee; and the states of Florida and Texas.

Despite the industry's steps toward maturity, there are a number of hurdles to overcome. One—the need for industry standards—is a concern voiced by the American Soybean Association.

Well aware of the need for standards and better quality control, the Soyfoods Association currently is working on establishing industry standards for both sanitation and composition of soyfoods to ensure product integrity and to protect consumers.

According to Austin, a primary priority for the association is to establish standards for tofu. "Tofu is marketed as a fresh product, unpasteurized and unrefrigerated. We see the need to protect consumers as well as the industry. We want to set standards for this."

Currently, tofu has varying protein and water contents, depending on preparation method, coagulant used and the grade and protein content of the soybeans. Also, its calcium and magnesium contents can vary according to the coagulant used.

Once it has finalized such standards, the association hopes to present them to USDA for review and possibly official adoption.

Association members also see a need to establish standard definitions for soyfood products to help consumers know what they are buying.

"The food has to be defined. Most are non-traditional American foods. We need to explain in American terms what these products are," Austin says. The label "soy sauce," for instance, is currently used both for chemical soy sauce and brewed or fermented soy sauce. "These are significantly different products," Austin says.

Such steps, industry members believe, will help make easier their task of making soyfoods the food of the 1980s.

Feature

# Tomsun: largest East Coast soyfood factory

Soyfoods, first produced in the United States by Oriental immigrants, now are manufactured by Caucasians as well.

The largest non-Oriental-run tofu company in North America can be found in the small northern Massachusetts town of Greenfield. Here, Tomsun Foods operates the largest soyfood factory on the East Coast.

Tomsun Foods opened in 1977 as the Laughing Grasshopper Tofu Shop. It changed its name to the New England Soy Dairy a year later and in 1983 renamed its main brand to Tomsun Tofu, which, it perceives, has both an American and Oriental touch. The business was renamed Tomsun Foods in 1984.

The company makes an average of 45,000 pounds of tofu a week. Its primary market is Boston and New England–chiefly Caucasian–where it does 50% of its business in firm and soft tofu, herb and spice tofu, and such products as egg roll skins, won ton wraps, fresh Chinese noodles, ginger soy sauce and five-spice powder. Another 40% of its business is done in metropolitan New York, with the remaining 10% centered in Philadelphia and Buffalo. However, company president Tom Timmins explains, "We want to be national within 10 years."

Currently, the company's products are in most all of the large supermarket chains from Buffalo to Philadelphia.

Tomsun Foods is a good example of a company that has effectively promoted soyfoods. Timmins admits that marketing tofu is not as easy as some products, particularly in non-Oriental areas, because people must be educated on its value and how to make it palatable, and because it is easily perishable. Despite such obstacles, the company has met with success. For instance, in 1983 *Inc.* magazine listed the company as No. 254 of the 500 fastest growing privately owned companies in terms of sales over the past five years.

Timmins credits this success in part to a changing publicity campaign. "We've had three different approaches. In 1981-1982, we stressed that it could be used in American diets. During 1982-1983, we promoted it as an Oriental food. In 1984, we're back to showing how tofu is a nutritional food. It has no salt, no sugar, no cholesterol. And that approach is timely, with Americans very aware of health issues."

A second strategy has been to cooperate with supermarkets to promote tofu by buying space offering special prices in supermarket ads published in newspapers, by giving in-store demonstrations and by holding cooking classes for several hundred people at a time.

Tofu, company employes point out, is very versatile. It can be grilled, fried, baked, steamed, boiled, scrambled, barbecued, marinated in sauces, crumbled raw in salads, added to soups, used in sandwiches, deep fried as tempura, whipped into puddings, dressings, dips, mayonnaise, spreads, appetizers and pates; added to egg, fish, vegetable or grain casseroles; used as the base for cheesecakes, pies, tarts and custards; or used in spaghetti, ravioli and manicotti. It also can be frozen.

It is this message that marketing director Madeline Fox and Judy Roberts take to their cooking classes and to television interviews.

"In our classes, we teach people the general philosophy of Oriental cooking and ways of cutting down on sodium. We show them a different and interesting way of cooking and making meals people like to eat. We teach them the techniques and how they can fit into our lifestyles," Fox says. Because the cooking classes are seen as free consumer education, they are often given coverage by local media as well.

The company also distributes a cookbook, "Delights of Tofu," which explains, "This cookbook is an introduction to a new concept in American dining. We have designed the recipes to make you feel at home with tofu while you experiment with new cooking techniques."

In addition, it has a New York agent who contacts television stations when the story of soyfoods seems to tie in with a topic in the news. "As a result, we're sometimes asked to do a two-minute spot or a half-hour cooking lesson," Fox says, explaining that the company has done this in conjunction with the topic of cholesterol and health.

Fox has noticed a change in consumer attitudes toward soyfoods over the past four years. "A lot of people resisted tofu at first. Some thought it was just a fad and would go away. Now they realize it's here to stay. And, with the findings on cholesterol and the growing presence of tofu in supermarket food cases, people want to learn how to use it. They are eager to learn."

The high protein tofu is made by first soaking soybeans overnight in water. They are then ground into a slurry which is cooked under pressure to remove anti-digestive enzymes. The liquid soymilk is separated off, with the solids sold in truckloads by Tomsun to farmers for animal feed. Calcium sulfate and magnesium chloride (nigari, an extract of seaweed) are added to the soymilk as coagulants. The resulting curds are pressed together until firm, cut into pieces, packaged, pasteurized and chilled. The company also places a recipe on the bottom of each package–another way to promote consumer interest in using tofu.

The finished off-white tofu cake can be firm or soft in texture. It is bland in taste with a consistency like a soft or cottage cheese. Because some people do not like the cottage cheese type texture, Fox says, the company is developing products in which the texture will be changed but the attributes of tofu will be retained.

While different companies making tofu obtain varying protein contents in

their product, Tomsun Foods produces a soft tofu with 8½% protein and a firm tofu, using more soybeans, with 11½% protein content.

Timmins explains that Tomsun is the only tofu company in the United States with an in-house laboratory. "Our competitors think we're crazy but we think of this as a long-term investment." Saying his company wants to do for tofu "what Frank Purdue did with chickens," Timmins believes that establishing quality control and quality assurance in its product can help achieve that.

"We are working on the day-to-day assurance to produce a uniform product and one that meets the requirements of the consumer," company laboratory manager Dan Drollette, a microbiologist, explains. "This is a relatively new industry, and there are no standards set by the government. We are somewhat on our own. What we're doing is trying to improve our product, basing it on our past experience, our product last week, last month, last year."

Drollette's work involves studying both organoleptic qualities for consumer appeal and microbiological aspects for consumer safety. "We know our product tests well as far as safety, but we must work more on the organoleptic aspects, to find out what consumers want, for instance, in color and texture."

Tomsun Tofu, Drollette and Timmins point out, has been designed to still be fresh after 28 days if stored at 48 degrees.

It is not surprising to see the company's concern over safety and standards, because Timmins is chairman of the Soyfoods Association of America's Standards Committee's board of directors, which has been working on standards for tofu. Pointing out that Japan's 30,000 or so tofu manufacturers which basically run cottage operations have standards to follow, Timmins sees the need for similar guidelines for the industry in the U.S.—for peace of mind both for the manufacturers and for the consumers.

Even if guidelines drawn up by the Soyfoods Association are set for voluntary compliance, Timmins sees this as valuable. "It will be an important start for our industry," he says.

## Soyfoods used in anti-hunger programs

*"Governments cannot force people to eat 'nutrition' because the majority of the people are not nutrition-minded. Poorer people will not eat specially prepared 'poor people food,' even if it is free. They want to eat what rich people eat."*

—Gil Harrison, American Soybean Association, Mexico City Office, at the 1980 World Conference on Soya Processing and Utilization.

In efforts to reduce malnutrition and hunger, a variety of soy protein fortified foods has been introduced throughout the world. The Food for Peace program, for example, has brought soy-based foods to many countries where local sources of vegetable protein were not readily available. Other groups, such as the International Soybean Program (INTSOY) at the University of Illinois, have promoted soyfoods in developing nations.

In its May 1984 U.S. Soybean Production and Utilization Research report, the Soybean Research Advisory Institute concedes that "even though it is probably one of the most thoroughly researched foods, the full potential of soy protein remains unrealized. The reluctance of consumers and the food industry to accept soy protein is due to factors that include protectionism by traditional protein interests, regulations, flavor and incomplete understanding of the nutritional and functional contributions of soy protein products. However, the primary problem is the real or perceived image of soy protein as a low-quality substitute for more traditional foods."

Lun-Shin Wei, a University of Illinois professor active in the INTSOY program, explains, "For soybeans to provide nutrition in the diet, people have to accept the soybean as a soybean." INTSOY's concept of fitting it into the cultural background and traditional diet, he says, is a positive approach to promoting soy use.

INTSOY officials cite Sri Lanka and Costa Rica as models for other countries seeking to supplement diets deficient in calories and proteins. In both countries, efforts by INTSOY and other agencies have resulted in an indigenous processing industry using locally produced soybeans for domestic consumption.

Interest in soybeans as a crop and food in Sri Lanka began in the early 1970s. In 1975, INTSOY signed a contract to aid the Sri Lanka government in implementing a soybean development program. A Soybean Foods Research Center, with a training facility and pilot plant to develop and produce soyfoods, opened in 1979.

"When INTSOY went into Sri Lanka, you couldn't even buy soybeans in Colombo, the country's capital. Now, soybeans are widespread. Most people have tried soybeans and are using them," A. I. Nelson, another University of Illinois professor affiliated with INTSOY, reports.

Part of the strategy has been to disseminate village-level technology including recipes for using soybeans, soy flour or soy beverages.

Nelson explains that traditionally, Sri Lanka natives used coconut milk in a spicy sauce on their vegetables. After a cyclone-tornado destroyed many of their coconut trees, a powdered soymilk was developed to be used in place of the coconut milk. "People can't tell the difference," he says. One factory

to produce the powdered soymilk was built and is now in use.

Nelson believes India "may be where things will start to happen" for more soy consumption. A soymilk plant using a process based on that developed at the University of Illinois already is in operation outside of New Delhi. Agreeing with Nelson's assessment, Dr. Wei says people in India are receptive to textured vegetable protein products. "They add a lot of spice to it. It has a texture like meat," Dr. Wei says, explaining that such a product fits into their vegetarian lifestyle.

Dr. Wei reports that Nigeria, India, Zambia, Cameroon, Turkey, Belgium, Ethiopia and Thailand are among the countries which have expressed interest to INTSOY in improving their soybean use. "For instance, people want to know how they can make better soymilk without off-flavor, without waste, while producing a highly nutritious product," he says.

Less soybeans are needed to produce soyfood products than for crushing beans for oil extraction, an important consideration for developing countries interested in soybeans. Wei and Nelson point out that a small solvent extraction plant might use 100 tons of raw soybeans per day, for a yearly total of 33,000 tons of soybeans based on 330 operating days, while a modest size soy beverage plant could produce approximately 20,000 liters of soy beverage a day from two tons of soybeans, for a yearly total of 660 tons of soybeans based on 330 operating days.

In Peru, INTSOY has worked with industry toward commercial introduction of soybean products including a beverage in both liquid and powdered form. The U.S. Agency for International Development and the Peruvian Ministry of Agriculture and Food also have worked on developing soyfoods in Peru.

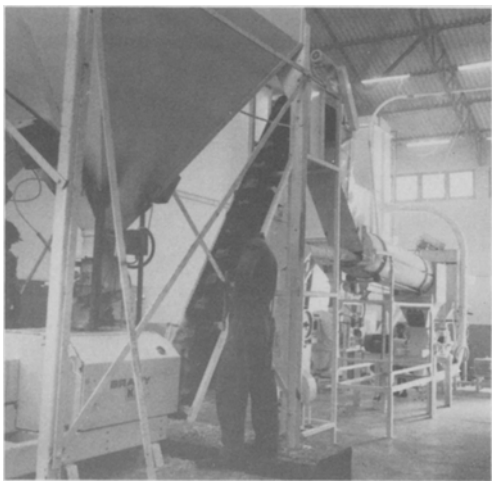
In Mexico, the development and commercialization of a nutritious, low-cost infant formula, Soyavén, based on soy and oats and fortified with safflower oil, earned the 1983 Food Technology Industrial Achievement Award. The powdered infant formula was designed by a Mexican research organization and manufactured by a Mexican company as an inexpensive source of nutrition for infants whose mothers could not adequately breastfeed and could not afford infant formulas on the market.

Meanwhile, the Latin American Human Nutrition Center developed by the American Soybean Association and based in Mexico City promotes soybean use. The center shows nutrition leaders from Latin America how to use soybeans and soybean products to help improve nutrition.

Dr. H. E. Kauffman of INTSOY says program leaders are optimistic that other countries will want to develop such protein sources. However, he adds, INTSOY itself does not have adequate funds to continue soyfoods research.

"Our immediate goal is to obtain more funds to be able to promote more research and use of soyfoods," he says.

**Feature**



**The low-cost extrusion cooker (LEC) program developed at Colorado State University has resulted in this production facility in Sri Lanka. (photo courtesy Colorado State University)**

# Low-cost extruder promotes soy uses

A low-cost extrusion cooker (LEC) program developed 10 years ago at Colorado State University provides technology to developing countries to make food-grade products from oilseeds on a small scale.

According to research associate Ron Tribelhorn, the university project has been supported by Agency for International Development funds channeled through USDA. Its first tasks were to test the limitations of the low-cost extrusion cookers and to experiment with protein foods that could be made chiefly from soybeans and corn.

"Our purpose was to provide a technology which could be used in developing countries to make food and and food items primarily for weaning-age children and also for pregnant and lactating women," Tribelhorn says.

The cooker, which inactivates the enzyme that promotes hydrolytic rancidity, produces such products as full-fat soy flour, precooked corn meal and blended foods.

Experiments included combining various oilseeds and a variety of cereals to make foods that provide energy and protein. Tested were cottonseed, peanuts, soybeans, rice, corn, sorghum, wheat, potatoes and cassava.

"We tried a number of oilseed and cereal combinations because developing countries would want to use whatever is indigenous. However, we like to work with soybeans because they are an economic source of protein and fat. If you combine soybeans with cereal, you get a reasonably balanced protein," Tribelhorn says.

One aim was to supply an extruder and stationary diesel engine of 350 to 500 kilos an hour to an interested group, "usually a government entity such as a university or a research center." Local people then were trained to use the machine and allowed to test it and develop a food. One center taking part in this initial step was the Institute of Nutrition of Central America and Panama (INCAP) in Guatemala.

A second phase was to demonstrate the capability of low-cost extrusion cookers to operate in a production facility setting. "The cooker could be used in production facilities and run on a fairly continuous basis to provide a suitable food for domestic use," Tribelhorn says. Four locations—Sri Lanka, Tanzania, Costa Rica and Guyana—have such demonstration facilities. Each has used indigenous grains, soybeans, corn or rice to produce mostly weaning foods.

In Costa Rica, the technology has resulted in a facility which produces a nutritious drink called "Freschorchata" made from corn and soybeans and sweetened with sugar for use in the school feeding program. "These types of drinks, made in powder form to be mixed with water, fit in well with feeding programs there," Tribelhorn says.

The world's largest production facility now using low-cost extrusion cookers is in Sri Lanka. "There two low-cost extrusion cookers are being used," he says.

Currently, Colorado State's Department of Agricultural and Chemical Engineering helps design low-cost extrusion cooker production facilities, trains start-up crews and conducts feasibility studies on a consulting basis. "We are willing to work with anyone—governments or private concerns—and charge on a cost recovery basis for our services," Tribelhorn says.

Tribelhorn is the only Colorado State staff member involved fulltime in the program, while Dr. Judson Harper, Colorado State's vice president for research, is principal investigator.

The department's latest project with low-cost extrusion cookers is investigating stabilization of rice bran to enable production of an edible oil. "We want to demonstrate that LEC can be used to make recovery of rice oil from bran economical," Tribelhorn says. For this project, the department is shipping equipment to the Philippines to demonstrate the process.