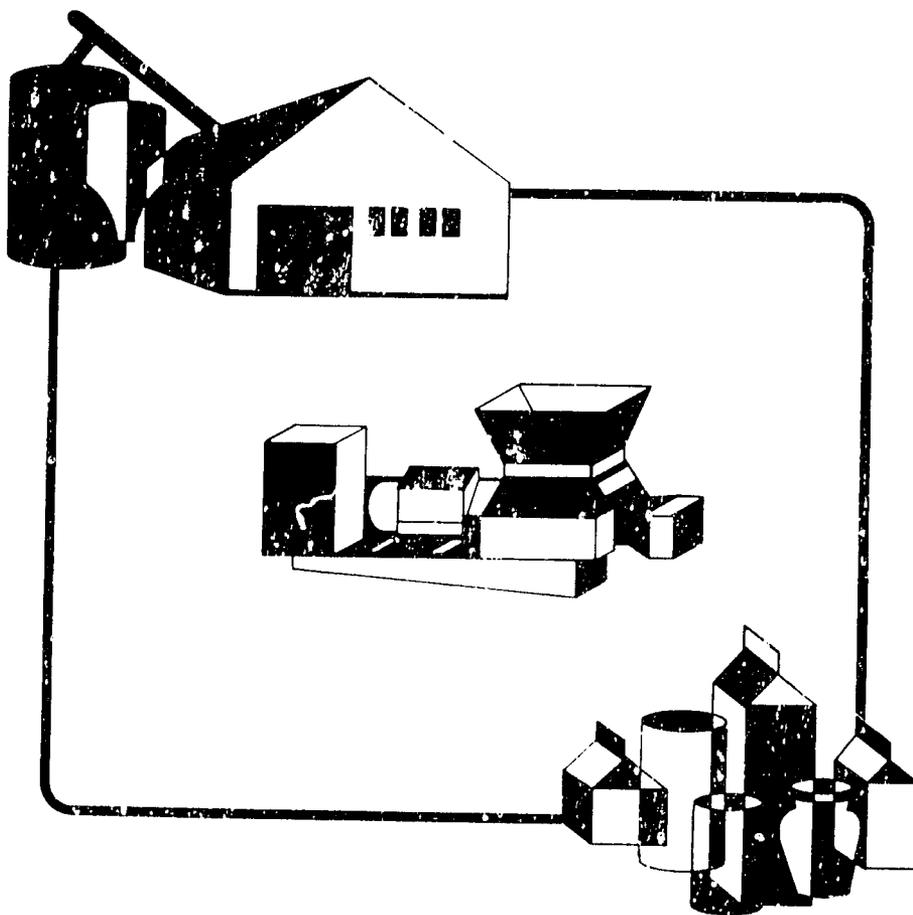


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THE CHIHUAHUA PROGRAM

AN APPLICATION OF LOW-COST
EXTRUSION TECHNOLOGY



Prepared by
Bern Keating
and
Robert Weil
for
U.S. Agency for
International
Development
Washington, DC
September, 1983

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Preface

This is the second in a series of descriptions of innovative or unusual nutrition programs with a food technology component.

Over the years AID has assisted countries to develop their own food processing capability for feeding and commercial programs. Low-cost extrusion technology has proved an efficient, yet relatively inexpensive, basis for establishing such capability. AID has provided both technical and financial assistance to help set up factories using this approach. A recent activity in Chihuahua, Mexico provides a striking example of the application of this technology. Here, a Mexican group established low-cost extrusion plants in a very short time and went on to not only maintain the equipment but even build some of it locally. They did all this almost entirely without external assistance. It is hoped that this account of the Chihuahua experience will be of interest to others engaged in program development work.

This piece has been prepared by Bern Keating, a technical writer and Robert Weil, a member of the Nutrition and Agribusiness Group of the U.S. Department of Agriculture.

Martin J. Forman
Director, Office of Nutrition
Agency for International Development

OVERVIEW

A program of soybean extrusion in Chihuahua, Mexico, provides an instructive example of successful use of extrusion technology for low-cost production of nutritious foods from locally grown crops. Many countries have been interested in processing foods from local resources for public feeding or commercial distribution to target groups. But the typical high-production U.S. processing plant is too expensive to build and maintain where only moderate output is required. Rather, smaller low-cost plants are needed and these plants must also be simple enough for maintenance in a developing country. Finally, an efficient means of distributing the product must also be found. In Chihuahua, Mexico, a state technological institute solved these problems in a program that should be of interest to others considering the development of low-cost programs to process foods from local crops.

The Chihuahua program was established in a relatively short time and with only minimal outside assistance. One factory now produces full-fat soy flour which is sold as an enriching agent to private manufacturers and to the Mexican Government chain stores for fortifying tortilla flour, the basic food of most Mexicans. A second factory supplies a feeding program for Indian children with a soybean-fortified corn flour, as well as providing a non-fortified flour for commercial distribution. A third plant sells reconstituted soy fortified milk through stores serving low income groups.

The three plants were built within two-and-a-half years and with a total investment of only

\$700,000. They operate with only 25 employees. They have run on a continuous basis with only local maintenance. In fact, Chihuahua technicians and mechanics have not only maintained the equipment, they have also built from scratch all the machinery for one of the plants.

What made the Chihuahua program work? Observers of this program stress three major factors. One was the technology used, low-cost extrusion. Factories used this technology to produce the same type of foods manufactured in much larger plants but in quantities needed by an intermediate size program. The smaller plants lowered requirements for capital and operating personnel and yet retained comparable cost per unit output. Further, the equipment was much simpler to maintain. These advantages were achieved not by scaling down large units but by adopting simplified manufacturing technology.

A second factor critical to success was the exceptional leadership provided by a small group of technicians on the staff of a state technical institute, CIATECH,¹ who made the technology work. They provided guidance to set up the factories and install the equipment. Later, they even manufactured the equipment themselves and set up training schools on its use for students from outside the state. They persuaded private investors to finance and subsequently run the factories. They also interested both private companies and government agencies in purchase of the products. The Chihuahua program is a case where technical personnel, in addition to their other responsibilities, were effective in moving outside of their accustomed role to address all the elements required to make a program work.

A third important factor was government sup-

¹Centro de Investigaciones y Asistencia Tecnológica de Estado de Chihuahua, A.C.

port. The government purchased a major portion of the products produced for use in several nutrition programs. While a demand was established in the private sector, government markets greatly expanded that base. That government support was not simply a subsidy aimed at maintaining the activity or helping it through a start-up phase. Rather, the program operators had convinced government agencies that their products should be used to improve ongoing agency programs. Government support was developed by meshing this new activity into existing programs to which the government already gave priority. High level government con-

tact and interest also played a key role in the Chihuahua program.

In Chihuahua, technology, leadership and government support interacted to produce an effective program. It is hoped that an account of the steps through which the program progressed will illustrate this interaction and be of interest to others interested in developing local food production programs.

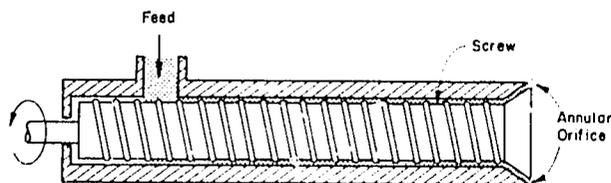
Before describing this evolution, let us first take a look at the tool on which the program was based, the technology used.

THE TECHNOLOGY

Armando Camacho, Director of CIATECH, first saw soybean extrusion with the low-cost Brady extruder in Costa Rica. He visited Colorado State University to consult with U.S. engineers experienced in the extruders and was persuaded that the technology was suitable for use in his agricultural state where soybeans were already a major crop.

What impressed Sr. Camacho was the simplicity of the process which produces a processed food from local raw materials in one operation.

As shown in the illustration below, raw cereals or soybeans are passed the length of a screw by its worm drive action and are worked and heated by the friction of the screw itself. The raw material emerges from an orifice as a cooked flake.



Action of extruder screw

During the 60-second passage, this single process simultaneously:

- replaces the raw flavor with a pleasant toasted taste;
- makes the product more digestible by gelatinizing the starch and partially coagulating the protein;
- enhances storage life by destroying microorganisms through heat generated by the screw's friction;
- deactivates chemical factors present in soybeans and other oilseeds and pulses which interfere with the body's ability to use their protein.

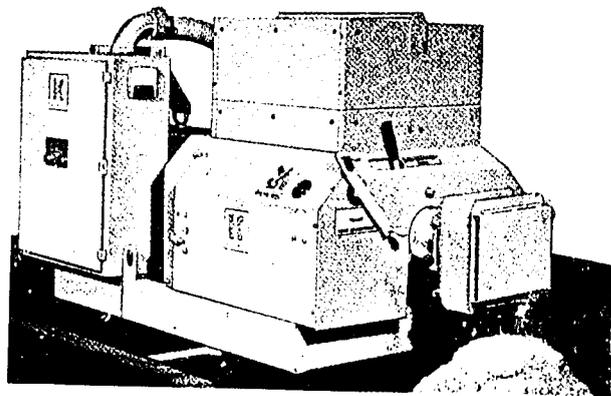
The result is a precooked food which still retains the fat and protein of the raw material.

The extruder chosen by Sr. Camacho was the Brady 2160, originally designed for processing cattle feed in small feed mills. The device is an adaptation of a portable model designed for a farmer to hook up to a tractor's power takeoff, so it was from the beginning engineered for operation and maintenance by persons of modest technological skill and training.

Besides being simple to operate, the Brady's size made a small plant possible for a limited investment. The total cost of the first Chihuahua plant was only \$262,000 as compared with the \$1 million to \$2 million cost of a large U.S.-type plant. The Brady could not produce shaped or textured products like a large extruder, nor would it have been most efficient if a very large output were re-

quired. But it was just as effective in producing in more limited quantity a blended food similar to the U.S. manufactured Instant Corn Soy Milk. It could also produce full-fat soy flour. Besides, because the Brady process bypasses the moistening and subsequent drying steps of the larger machines, it turns out its products at the same unit cost.

The availability of a technology that was simple and low cost was critical for establishing the program. The other critical factors were the vision and commitment of the Chihuahua technical personnel, and the interest and support of the state and federal government.



Brady 2160

PROGRAM GENESIS — THE PLANT AT DELICIAS

The Chihuahua program began when Manuel Bernardo Aguirre, governor of Chihuahua, wondered if the soybeans his agricultural state produced, the fourth largest state production in the Republic, could be converted into a nutritious supplement for traditional staple foods. He turned to Armando Camacho who, as the director of the newly-organized CIATECH, headed a staff of engineers and scientists charged with using modern technologies to attack the social and economic problems of the region.

Although Chihuahua's soybean production was large, most of the crop was exported to other states where only the oil was extracted for use as human food and the residue was used for cattle feed. Sr. Camacho and the governor agreed that they had to find a means of making cheap full-fat flour which would use the entire soybean.

A short time later, while attending a conference of the American Soybean Association in Mexico City, Camacho met Gilbert Harrison, an official of the Association, who told him about a low-cost extrusion cooker that could convert soybeans to an edible flour rich in calories and protein. Harrison advised Camacho to consult the Agricultural and Chemical Engineering Department at Colorado State University because the scientists and technicians there had been providing technical assistance for some time for the development of small



Armando Camacho

factories using low-cost extrusion cookers (LECs). This work was supported through an agreement

with the U.S. Department of Agriculture with funding by the U.S. Agency for International Development.

The leader of the Colorado Group, Dr. Judson Harper, suggested that Camacho visit Costa Rica where an extruder was being used in a local program. He also sent CIATECH samples of whole soybean flour produced by a low-cost extrusion cooker.

As a next step, Camacho met with 15 members of a soy producers cooperative in Delicias, close to the state capital, whom Governor Aguirre had arranged to bring together. Camacho sought to build support for the financing of a full-fat soybean flour factory by showing the producers how low-cost extrusion could develop new demands for soybeans to increase the crop's value.

With travel financing provided by Governor Aguirre, Camacho went next to Costa Rica where he met with Delbert Clark, manager of the Pronutre Company, and observed use of the company's extruder to make a pea soup mix for Costa Rica's school feeding program. He also studied a program being developed by CARE to combine soy farming with extrusion processing.

Impressed by the Costa Rican experience, Camacho began laboratory experiments to test possible soy products. CIATECH personnel developed and tested milk extenders, soy-based drinks, enriched tortilla flour and fortified oatmeal. He and his colleagues also talked to Chihuahua bakers who were already using full-fat soy flour as a partial substitute for eggs. They indicated willingness to use a local product instead of the flour produced by a large US-made extruder in Mexico City.

In May 1977, three months after the Costa Rican trip, Camacho and two of his associates, Hector Acosta and Francisco del Valle, went to Colorado to consult with the university team. During two-and-a-half days of intensive talks, the Chihuahua team and the Colorado experts sketched the rough design of an LEC factory.

Armed with a specific proposal, CIATECH persuaded the Delicias soybean cooperative and other private investors to form in August 1977 a company called Productos Alimentos Delicias (PADSA), capitalized at \$300,000. CIATECH commissioned two market studies which concluded that soy flour could be introduced either as an ingredient in processed foods or as additive the housewife could mix with staples. The states of Durango and

Coahuila were seen as additional markets.

With that encouragement, CIATECH, acting as an agent for PADSA, supervised construction of an LEC plant designed for modest initial production, quickly expandable by adding shifts as markets developed.



The PADSA plant at Delicias

Besides the obvious tasks of picking a plant site, designing the structure and layout, and procuring and installing the equipment, including the vital Brady extruder, CIATECH supervised the manufacture of much of the supporting equipment in Chihuahua machine shops. During the construction period, electricity and water were brought in, equipment was tested and operators trained. Within nine months of the visit to Colorado, the plant was ready to produce. Ordinarily, such a project could have taken two to three years, but, with the leadership of Sr. Camacho and backing of PADSA, CIATECH reached decisions rapidly and completed the plant quickly. In March 1978, at the invitation of Governor Aguirre, Mexican President Jose Lopez Portillo came to Chihuahua to inaugurate the factory.

The Delicias plant built for PADSA is housed in simple structure, 50 by 150 feet. In a small inside area are an office, a quality control work room, and a storage room for manufactured stocks. Surrounding this area in the form of an L is the main working space for manufacturing full-fat soy flour.

The production line begins with a storage bin for raw soybeans. The beans pass over a screen for

sifting out foreign matter and from there they go through a two-roll cracking mill to loosen hulls. Next they go to an air separator where hulls are removed. The cleaned dehulled beans are fed into the extruder screw where they are worked, cooked and extruded as flakes. The heated flakes go through a cooler and then a grinder where they are reduced to flour. The product is bagged at a weigh hopper into twenty-kilo sacks. The plant is run by a small crew of 12 men.



Interior of the PADS plant

CIATECH and PADS next decided to try marketing soy flour directly to consumers for enriching

²Gibbs, R., "CONASUPO Sells Basic Food Cheaply" *R&D Mexico*, Vol. 1, No. 12 (September 1981), P. 16-20.

wheat flour, soups, beans, and, in particular, masa, a precooked corn flour. Demonstrations in supermarkets and radio and television spots extolled the nutritional benefits of adding soy. Some initial curiosity buying occurred. But after a short time it became clear that the Chihuahua supermarket shopper had not been persuaded to buy soy flour to improve the home diet.

A more promising strategy appeared to be providing soy flour as an ingredient to be added by a food manufacturer. In the fall of 1978, contracts were signed to provide soy flour to two large cracker bakers in the cities of Guadajajara and Puebla, expanding PADS's market from the state of Chihuahua to the states of Jalisco and Puebla.

The Chihuahua group also turned their attention to a food which could reach large numbers — the tortilla which is the foundation of all Mexican meals at all economic levels.

Tortillas supply a significant portion of the calories consumed in Mexico. The corn flour which is used for tortillas is produced through a process called nixtamalization. Home preparation of corn flour using this process is a demanding time-consuming task. First, the raw corn grains are boiled in water and lye for an hour and a half to remove the bran and germ. After being drained and dried, the hominy is carried to a mill and ground between millstones, producing a cornmeal flour called masa. To escape this tedious process, commercially-prepared masa is bought not just by the middle class, but by lower income people in both urban and rural areas.

About half of the corn flour consumed in Mexico is processed by CONASUPO (Compania Nacional de Subsistencias Populares), a federal agency with a scope extending from market control of basic foodstuffs to retail sale of food products and other basic home supplies. In 1980 CONASUPO's sales constituted 9% of the Mexican retail market. Its products were distributed through 15,000 rural outlets as well as supermarkets and 1,000 smaller urban stores. Its outlets included mobile units, some housed in freight cars and others in small boats to serve river populations. To penetrate outlying areas, its transportation fleet even included some 1,000 mules, in addition to trucks and cargo planes.²

The intention of CIATECH and PADS was to

see if CONASUPO could be interested in adding soy to the tortilla flour it sold. This addition would increase the nutritional value of the protein in the tortilla. Soy has a higher protein content than corn. In addition, of greater importance nutritionally, soy flour contains large amounts of lysine, an amino acid which is insufficient in the protein found in corn. These two effects would increase the nutritional value of the digestible protein in the mixture by almost half. In addition, the very high fat content of soy flour would increase the calories available from fat in the enriched flour by about one-third over normal corn flour, which is low in fat.

As a first step, Sr. Camacho presented to President Lopez Portillo, during one of his periodic visits to Chihuahua, the proposal to add soy to tortilla flour for enriching the Mexican diet. The President expressed interest, and, as a followup, Camacho met with Jorge de la Vega Dominguez, Federal Minister of Commerce and Industry. Dominguez agreed to try soy fortified tortilla flour in a small acceptability test. A 60 family study was conducted over a 30-day period. The experiment showed that a fortified tortilla flour could be produced that had no soy flavor.



President Lopez Portillo testing a tortilla made with enriched corn and soy.

The Dominguez staff reviewed the study and, after a series of meetings with Enrique Diaz Ballesteros, Director of CONASUPO, on June 26, 1980, a contract was signed providing that PADSA would furnish CONASUPO 250 tons of full fat soy flour per month. The contract required the Delicias plant to go on almost round-the-clock production. CONASUPO agreed to transport the soy flour to two large private manufacturers of tortilla flour in Chihuahua City and Monterrey where it would be added to tortilla corn flour as an enriching agent.

Essential to the plan was CONASUPO's agreement to underwrite the cost of soy flour as part of its program of providing a partial subsidy of selected consumer items like coffee and sugar. This permitted fortified tortilla flour to be sold at the same price as non-fortified flour. The new product was in fact simply substituted for the old on the shelves of the CONASUPO stores where it was offered.

The Government's purpose in purchasing the soy flour was improvement of diet, though providing a market for the soybean farmers was probably also a factor.

In December 1982 the PADSA plant's contract with CONASUPO expired. Because of severe inflation, depressed economic conditions, and a change of administration, CONASUPO cancelled subsidies for coffee and sugar and also the continued soy enrichment of corn flour. By May of 1983, however, after review by the new Mexican administration, a new six-year contract was negotiated, and CONASUPO agreed to continue to buy 250 tons of soy flour per month from the Delicias plant.

The tortilla flour produced under this contract is sold by CONASUPO stores in the states of Chihuahua and Coahuila. The 5,000 tons of soy enriched flour reach an estimated 800,000 people each day.

Beyond its primary use for tortillas, enriched flour is also used in other Mexican national dishes. Among them is the tamale, a dish made of a filling wrapped in a corn dough. Another is atole, a gruel made by boiling tortilla flour in water and then adding sugar or other flavors such as chocolate. Atole is consumed as a drink or porridge. Of particular significance, it is also used for weaning children, so that the enriched flour improves the

weaning diet.

Besides producing soy flour, the Delicias plant also uses the extrusion process to manufacture a soy-oats-sucrose mix for an infant formula. It is marketed as Soyaven.³ In 1982 the mix sold for about two-thirds the cost of the least expensive milk-based formula though it had equivalent nutritional value. Also, because milk is not an ingredient, Soyaven is suitable for lactose-intolerant children whose systems have difficulty accepting milk. Soyaven is distributed through drug stores as well as supermarkets, clinics and the CONASUPO chain. Besides the state of Chihuahua, it is sold in several other states and Mexico City.

In 1983 the U.S.-based Institute of Food Technologists recognized the development of Soyaven with its annual Industry Achievement Award. Honored were PADSA and a newly-formed nutrition research organization, Fundacion de Estudios Alimentarios y Nutriciones, which had worked on

the formulation and testing of the product.

At Delicias an idea had been transformed into a healthy operation. Good leadership had taken advantage of an effective technology and, with the help of government support, had established a vigorous program. About twelve tons of product are turned out daily. Full-fat soy flour is supplied to CONASUPO, commercial bakeries and cracker manufacturers, and the soy-oats mix, Soyaven, is also produced.

Something that in the long run may prove of even greater importance was also accomplished. The Delicias plant gave an affirmative answer to Governor Aguirre's original question; i.e. could a state which produced soy in large quantity turn some of that production away from export to out-of-state markets, where a significant part of the soybean was utilized as animal feed, and use it instead to improve human diet. The Delicias operation showed that it was possible.

THE PLANT AT CUAUHTEMOC

The Delicias plant was a long first step in using relatively simple technology to manufacture nutritious foods. A further important development was the establishment of a second plant at Cuauhtemoc a year and a half later.

From the beginning, as the staff of a technology development institute, Camacho and his colleagues were interested in improving local technical skills.

"It was important to manufacture our own equipment and develop our own technology, rather than import it," Camacho observes.

So when the Delicias plant was established, CIATECH sought to manufacture in local machine shops some of the ancillary equipment supporting the extruder.

Encouraged by the accomplishment of the local machinists, CIATECH decided to see if an ex-

truder, itself, could be built in Chihuahua. CIATECH personnel again worked through local shops to produce and assemble a complete 75-horsepower machine. During one of President Lopez Portillo's visits to Chihuahua, CIATECH was able to put on a live demonstration of a home-built extruder. When the President witnessed the locally-made machine in action, Camacho says "he responded with emotion and asked what would be needed to put such a machine in operation." Informed that a small plant could be established for something over \$200,000, he turned to his aides and told them to provide assistance.

A series of meetings with federal and state officials followed. As finally worked out, the Mexican-built extruder was to be located in a factory which would be owned by Chihuahua State. Its construction would be jointly funded by Chihuahua and the federal government. The plant's site would be Cuauhtemoc, a town near the Sierra Madre mountains. Here it would directly serve the Tarahumara Indians providing, in particular, a fortified food for their school feeding program. As at the Delicias plant, CIATECH would act

³del Valle, R.R., "Industry-Government Nutritional Improvement Programs: An Experience in Mexico." *Food Technology*. Vol. 36 No. 10 (October 1982), P. 121-9.



Manufacture of extruders in Chihuahua



The Cuauhtemoc plant

as agent for the design and construction of the plant.

Going beyond construction of the extruder itself, CIATECH created a plant in which all major equipment was Mexican-built. Local machine shops made the grinders, conveyors, cleaners, air separator, hoppers and chutes. CIATECH directed assembly and testing of the production line. In December 1979, a full plant went into operation, only seven months after the decision to go ahead.

The Cuauhtemoc plant supplies 30 tons per

month to the 75 participating Tarahumara schools. The flour makes tortillas provided as part of three daily meals for Indian children boarding at the schools during the week.

Besides the school feeding, the Cuauhtemoc plant also provides about 140 tons of pre-cooked corn flour per month to selected CONASUPO stores in Chihuahua and the neighboring state of Zacatecas. This corn flour is not now fortified with soy, but the contract does keep the factory working at full capacity. The factory may supply fortified flour in the future.

A question often raised about technology transfer is whether the equipment is simple enough to be maintained locally and whether replacement parts are available. In Chihuahua local technicians and mechanics not only maintained the equipment, but even built their own version from scratch. Further, this equipment was produced not in a large factory but in several modest local machine shops supervised by a small state-operated technical institute, CIATECH.

The Delicias plant had turned out as its main product a soy flour which was then mixed at another site with tortilla flour to form a blend. In contrast, the Cuauhtemoc plant produced a flour that was precooked in a single step. The corn-soy blend is similar to that supplied by factories costing several million dollars. But at Cuauhtemoc, a much smaller plant produced the lesser quantity needed at a comparable cost. As a result, it was possible to proceed with a locally-supplied feeding program without heavy investment of capital or labor.

In summary, at Cuauhtemoc the Chihuahuans showed they could not only maintain low-cost extrusion equipment but even manufacture it. And, as with the Delicias plant, they went from first approval of the project to production in an extremely short time. The Cuauhtemoc experience also illustrated the feasibility of producing a precooked blended food for use in a feeding program without large capital investment or manpower requirements.

ALBACHISA

Besides the two main plants at Delicias and Cuauhtemoc, CIATECH also set up a pilot milk reconstitution plant run by three men at a cost of \$174,000.⁴ This plant is located at Nombre de Dios on the outskirts of Chihuahua City and is owned and operated by small company formed for this purpose. It was completed in the fall of 1979.

The Albachisa plant was established to help expand the uses and markets for soy flour. It has demonstrated that reconstituted milk can be extended by soy and will be accepted by low income groups. The Albachisa plant introduced Chihuahua to a nutritious lower-cost alternative to normal milk, and CIATECH hopes to introduce other states to this product.

The Albachisa plant gets soy flour from the PADS plant at Delicias and blends one part of soy to nine parts of milk powder in a large tank. The plant adds oil, sugar, water, and a stabilizer. The mixture is pasteurized for 50 minutes, passed to a storage tank and from there to a homogenizer. It is then cooled and packed in one liter cartons. Originally, the extended milk was bought by the state's DIF (Family Integral Development Agency), an organization that sells food to the poor through special government stores.

This small pilot scale plant did not have the pro-

duction economies of the large milk reconstitution plants in the area, but it got its milk powder from the State of Chihuahua at a reduced cost. Coupled to the low cost of soy, the plant could offer fortified milk at a somewhat lower price than normal reconstituted milk. From its beginning output of 800 liters a day in 1980, the plant built up to sales of 6,000 in 1982, enough milk to reach 25,000 people.

Because of a deteriorating economy, in late 1982 the state could no longer make available the low cost milk powder. The Albachisa plant could not compete with the large reconstitution plants, but continued on a reduced scale supplying two towns in the outlying Sierra. Besides the soy fortified milk, the Albachisa plant supplied a non-fortified orange drink to private stores in the two mountain towns.

In early 1983 Armando Camacho presented to the new Governor Oscar Ornelas the potential benefits of providing an orange drink fortified with soy and milk as an alternative to the soft drinks sold to school children by school stores. In May, under a new agreement, the state agreed to provide cheap milk powder to Albachisa again which would supply a fortified orange drink to Chihuahua schools and soy extended milk to DIF stores.

OTHER ACTIVITY

Demonstrations by the three plants established by CIATECH seem to be stimulating other activity. In 1980 private investors set up a small mixing plant to produce processed foods using full-fat soy bean flour bought from the Delicias plant. The most important product has been a soy-enriched

oat-wheat granola bar used in the school breakfast program. The bar provides about 130 calories. Served once a week to school children in Chihuahua City and several neighboring cities, the bar has the further advantage of requiring no preparation by the school staff.

⁴Griensen, A.C., "CIATECH: a Summary of Its Work Using Soya to Produce Nutritional Food at Low Cost." *Journal of American Oil Chemists Society*, Vol. 58, No. 3. (March 1981.)

OUTREACH AND TECHNOLOGY DISSEMINATION

With establishment of the plants at Delicias, Cuautemoc and Albachisa, the Chihuahua program showed the capabilities of low-cost extrusion technology for commercial and institutional programs. Building on this experience, CIATECH began promoting wider use of the technology.

In February 1980 a CIATECH team sponsored by CARE and funded by AID returned to Costa Rica, this time to provide the benefit of CIATECH's own experience. There they worked with the Costa Rican National Food Technology Research Center. The Center was interested in finding ways to use soy flour for new foods. CIATECH personnel advised on markets for soy flour and the development of food products using soy as an ingredient.

CIATECH also put on seminars at its home facilities to inform government and private industry at the national level about the technology and its potential. To provide an expanded training program, CIATECH set up a pilot plant housing a new locally-built extruder. Several training classes have already passed through the courses. CIATECH hopes that this training will be used not only by Mexican personnel but also by persons from other countries interested in launching low-cost extrusion programs.

To further LEC technology, CIATECH has recently designed and experimented with extruders



A point is demonstrated at CIATECH's new training facility

of different sizes. A 30-horsepower extruder, about one-third the size of a standard 75-horsepower unit, was built for testing. Its purpose is to serve a village where only a small amount of product is needed. At the other end of the spectrum, CIATECH has also built a 200-horsepower machine. This extruder will be used by a group in the Yucatan to manufacture animal feed. Sr. Camacho believes, however, that this machine may also serve as a prototype for an extruder which would produce soy or tortilla flour where demand requires very large output.

SUCCESS FACTORS

In a very short time, with few trained personnel and only modest financial backing, two LEC factories and a small milk-soy plant were built. And, except for limited technical advice, this was accomplished without outside help. After purchase of the first Brady extruder, the core equipment was made entirely in Chihuahua shops. The production capability established was joined to an effective distribution system to achieve a vigorous program.

What contributed to this achievement? In Armando Camacho's view, the most important factor was the technology. It was simple, required only a low investment and was easy to operate and main-

tain. It also was able to produce quantities small enough for an intermediate program at a unit cost comparable to output from much larger plants.

Camacho and several observers also emphasize the importance of government support. Camacho says "When you have support, you can fly if you want." The Governor of Chihuahua, Manuel Bernardo Aguirre, played one of the key roles here. He called together a group of soybean producers to consider formation of the company that subsequently funded the Delicias plant. He assured CIATECH of the funds necessary for important activities such as the trips to Colorado and Costa

Rica. Governor Aguirre also helped establish contact with President Lopez Portillo. Through the Governor's intercession, Camacho was able to talk to the President several times and to get into his hands reports of the program. These contacts opened the way to discussions with CONASUPO about the benefits of using soy as a fortificant in its tortilla flour program. This contact also helped obtain a federal contribution to the construction of the Cuauhtemoc plant. And more recently the interest of the new federal administration was essential to renewal of the CONASUPO-Delicias contract. Similarly, the support of the new state government has been important for the Albachisa plant.

Besides government support, participation by the private sector has also been important. Indeed, Camacho feels that CIATECH's success in obtaining governmental support through successive administrations is partly due to early involvement of commercial interests. Because private investors underwrote the Delicias and Albachisa plants and because the program gives a significant new outlet for soy producers, the program has built its own constituency.

Related to these other factors, observers consider CIATECH's role critical in bringing together solutions to the technical, organizational and political problems. On the technical level once CIATECH personnel were persuaded of the benefits of low-cost extrusion, they moved quickly to establish plants that used the technology, they showed that the extruders would produce efficiently and they further showed that local technicians could keep them running. Besides, they used their knowledge of local customs and tastes to develop and test products, to commission market studies and to conduct informal inquiries into market potential. It was CIATECH that took the initiative in seeking to determine whether the market potential presented a reasonably good business risk.

On the organizational side, CIATECH personnel took advantage of the favorable factors they found and helped make others materialize. For example, CIATECH worked with the private sector to promote the Delicias plant and to develop interest of food manufacturers in soy flour as a fortificant.

Finally, CIATECH personnel enjoyed the interest

of Governor Aguirre, and went on to build support at the national level. CIATECH took pains to disseminate reports on its work. CIATECH's director, Camacho, met with the President of Mexico several times. CIATECH joined Governor Aguirre in arranging for the President to inaugurate the Delicias plant. CIATECH's role persisted during the transition from one set of federal and state administrations to the next. For support from one administration did not automatically carry over. Rather, CIATECH needed to continue its efforts to interest the new administrations in its programs.



Soy enriched corn flour on a Chihuahua store shelf

A final factor, already alluded to, was economic viability. There had to be long-term demand for the factories' output. CIATECH addressed this question not only in the planning stage but on a continuing basis. Some observers believe its role here was at least as important as in introducing the technology. CIATECH's efforts to create general interest in soy-fortified foods have been noted. In

addition, in addressing specific consumer needs CIATECH found several principles important. It was not enough to produce a nutritious food in the laboratory. The product had to meet local tastes. In fact, the greatest success was reached by simply enriching tortilla flour, a product already universally consumed at all economic levels. CIATECH also found product promotion needed an economic rather than a nutrition appeal. Promotion of soy as

an enriching agent failed even among middle income shoppers, but was successful with all groups when provided as a tortilla flour ingredient at no additional cost. Similarly, soy flour became attractive to bakers only when it could reduce their costs. On the other hand, Camacho believes that for government agencies the most important factor was the improvement brought by soy-enriched products to Mexico's nutrition.

CONCLUSION

The Chihuahua experience illustrates that the production of local foods for nutritional purposes is feasible without high capital or a large number of highly trained personnel. Using low-cost extrusion technology, Chihuahuans showed that this could not only be done, but done in remarkably short time. Making their own equipment and moving very fast, the Mexicans actually went further to demonstrate an unusually effective application of the technology. The Chihuahuan experience suggests that the twin problems of how to achieve low-cost and simplicity of operation have a technological solution and that a program based on such tech-

nology can be made to work. It also illustrates the effective combination of technology, leadership and government support.

Those seeking further information on the Chihuahua program may write to CIATECH, Apartado Postal 1067, Chihuahua, Chihuahua, Mexico. In addition to answering inquiries, CIATECH is also sponsoring information seminars and training programs. For general technical information on low-cost extrusion technology, inquiries can also be addressed to Department of Agricultural and Chemical Engineering, Colorado State University, Fort Collins, Colorado 80523.