Technical

Conversion of Soybean Extraction Plant in Bolivia to Production of Flours for Human Consumption: Feasibility Study[1]

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ABSTRACT

During an on-site visit to a commercial soybean crushing plant in Bolivia, two engineers investigated the modifications required to produce a food-grade soy flour. Differences between processing for human food and for animal feed are described and the various processing stages were evaluated to determine their effects on finished product quality. These stages are: (a) pretreatment of the beans, (b) oil extraction, (c) meal desolventization, and (d) grinding and handling of the flour. Bacteriological control was maintained throughout the plant. The information gained from this study should be useful and directly applicable to other soybean crushing plants in the world.

INTRODUCTION

Recently, Bolivia was selected by the Agency for International Development (AID) as a target country to conduct a program of soy fortification of wheat products. Soybeans could provide an effective means for protein enhancement of the Bolivian diet. A feasibility project to implement the program was awarded to the Western Regional Research Center, Albany, California.

In the program, the composite flours would consist of rice and/or quinoa flour blended with wheat flour and fortified with defatted soy flour. The substitution of Bolivian rice, quinoa, and soybeans for part of the wheat flour will save foreign exchange on wheat imports and can be expected to stimulate Bolivian agriculture. In addition, the use of soy flour is an effective means for protein enhancement of the Bolivian diet (Fellers, D.A., A.A. Betschart, and R.V. Enochian, Report of Assessment trip to Bolivia, February 1977, Western Regional Research Center, USDA, Albany, California, unpublished results.) because of the high level of wheat consumption (135 lb/capita/year) in the form of breads and pastas.

During the past year, Bolivian soybean production has increased to nearly 30,000 metric tons. However, existing soybean extraction plants in Bolivia were constructed to produce oil and animal feed. For the soy fortification program, one or more of these plants must be converted to have the capability of producing edible-grade soybean flour. During August 1978, two engineers, one representing the Northern Regional Research Center, USDA, and the other representing EMI Corporation, a U.S. private engineering firm, visited the soybean processing plant Sociedad Aceitera del Oriente (SAO) at Santa Cruz to develop a plan for the plant conversion.

The major constraint on increased soybean production in Bolivia lies with the demand for the major soy byproduct, soybean meal. Without a demand for this byproduct, oil processing plants such as SAO at Santa Cruz face significant economic losses, even though the marketing of oil in Bolivia is no problem. A project such as the conversion to edible soy flour is, therefore, needed to provide expanded markets for the protein meal, give higher profit margins to the soybean crush, and increase utilization of domestic soybeans.

This report describes the steps and the modifications required to convert the plant to sanitary construction for both edible oil and flour production.

SEED HARVESTING AND QUALITY

Soybeans for the SAO plant were harvested in May and June mostly from areas north of Santa Cruz. The commercial varieties were Pelicano, Santa Rosa, and Halosoy. Planting time fluctuated between the 15th of November and the 15th of January. Some winter planting was done in the months of April and May.

Seed quality was very good, with the following approximate analyses:

	Range, %	Average, %
Damaged beans	0.2-10.0	<1
Foreign matter	0.2-10.0	<1
Splits		<5
Off-color	0.2-3.5	<0.5
Moisture	10.0-15.0	12.0

Visual examination of the beans indicated some occasional stones, small pods (open and closed), stems, weed seeds, black beans, and trash, but no dirt or filth.

In general, the quality of the beans appeared excellent.

EXISTING FACILITIES

The SAO plant is ca. 3 years old and was constructed by the Industrial Engineering Company (HLS Ltd.) of Israel. The plant is designed to process a maximum of 180 metric tons of soybeans or 250 metric tons of cottonseed per day. A block flowsheet of the process is shown in Figure 1 with the existing equipment shown on the left (white blocks).

FACTORS IMPORTANT IN A SANITARY FOOD PLANT DESIGN

Key factors or steps known to be important in plant conversion are (a) seed quality and cleaning, (b) bacterio-

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logical data relating to plant design and equipment, (c) seed tempering and new dehulling facilities, (d) control of bird, insect, and rodent contamination, (e) disposition of millstock and millfeed byproducts, and (f) addition of new facilities for protein dispersibility control and for flour grinding and classification.

With regard to seed quality, bean splits should be held to a minimum (probably 5% or less). A low level of splits results in low amount of contamination. Bacteria exist to a great extent on the hull and in the faces of splits. Large beans are better since more cotyledon is protected from bacteria. A complete bean cleaning before cracking and dehulling is critical in separating the bacteria-laden loose hulls and foreign matter. Before dehulling, whole beans should be dried to ca. 9-10.5% and tempered for 10 days or longer in order to facilitate dehulling. Condensation in hot meal lines should be minimized or eliminated by using steam-tracer lines and adequate insulation. A dust control pick-up system should be installed at various points in the existing system to reduce airborne particles in the preparation building and thereby reduce contamination problems. Several areas in the plant, including the storage area, have pits and tunnels that will require careful periodic cleaning to assure sanitary conditions. Other factors will be developed in the full process description of the SAO plant.

PRESENT LEVEL OF SANITATION–ON-SITE MICROBIOLOGICAL TESTS

As an additional effort to provide more data for the study, two sets of samples were taken throughout the plant while it was operating on soybeans. Microbiological testing was run by the procedures of Bothast et al. (1). Figure 2 gives a total plate count profile at various points in the SAO plant process. Stored beans were low in aerobic bacteria but reached 99,000 after passing through the cracking rolls. This high count does not reflect the relatively low count that would be expected if a front-end dehulling system were to be installed. Heat kill in the cooker reduced the plate count to 9500, where it remained low during flaking; but in the extractor, plate count increased to 103,000 from undetermined contamination sources. Heat in the desolventizer-toaster reduced the level to only 6400.

Total mold count of hulls separated from soybeans entering the plant process was high (1.31 x 10^6/g). Field dirt in the plant vicinity had a high plate count (4.9 x 10^6/g) and a high mold count (7.3 x 10^4/g). However, two calcium alginate swabs that were exposed to the air for 3-hr duration in the plant vicinity accumulated very few microorganisms (<100).

REDESIGN OF SAO PLANT FOR EDIBLE PRODUCTS

Capacities

With regard to capacity, it is important to understand that it is not feasible in any soybean processing plant to convert 100% of the production to edible protein products. Production of animal feed is still indicated and provides a means for disposing of cleanings, mill feed (from dehulling) and millstock, which are screenings containing dirt, weed seeds, and bean chips. Further, in the storage area it is not always possible to furnish the process with prime quality soybeans. At times there may be excessive splits and trash, which can contaminate the beans and result in inability to produce a clean, sanitary product. Also, for one reason or another, flour may be produced that is off-specification and must be rejected. This is accomplished by incorporating it into animal feed. It has been the authors' experience in the past that a producing plant can divert at least 25% of its

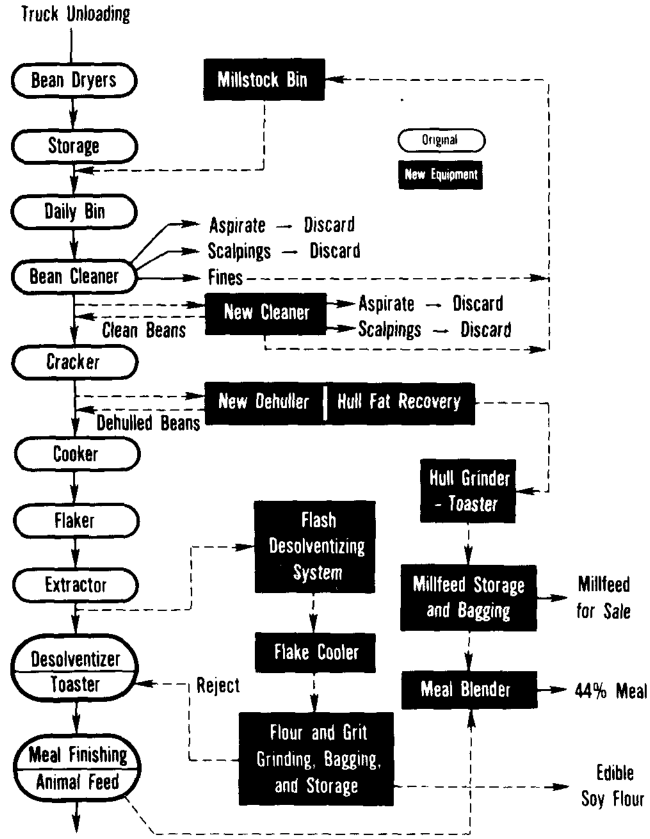

FIG. 1. Flowsheet of proposed SAO plant conversion to edible soy flour production.

extracted flake production as premium grade flour without seriously reducing the quality of the animal feed product. In the SAO plant, it was agreed that a 50-metric-tons-per-day (MTD) flour grinding system should be installed, with building space allowed for a second such unit.

Pretreatment of Beans

In addition to the original plant equipment, Figure 1 shows a proposed block flowsheet for converting the existing SAO plant to edible soy flour production; the proposed new equipment is shown as dark blocks whereas original equipment is in white blocks.

The process will begin with truck unloading into the three existing bean dryers. It is not feasible to provide for bean cleaning at this point, because the beans are received in a relatively short period and the required cleaning capacity would be excessive. Predrying here to under 10.5% moisture will prepare the uncleaned beans for 10 days minimum tempering storage in one of two existing Muskogee horizontal storage buildings having 20,000 metric tons capacity each. These storage units provide shelter from the weather, can be closed and screened from birds, and can be ventilated by aeration induced by suction through an existing tunnel system at the center of the building. Hot spots can be controlled by sending the beans to processing or cooled by concentrating aeration on them. Several pits for bucket elevators exist in various areas of the plant. As mentioned earlier, these pits are not conducive to good sanitation control of the process streams and will have to be cleaned regularly.

Seed Preparation

Tempered beans will be transferred pneumatically to the

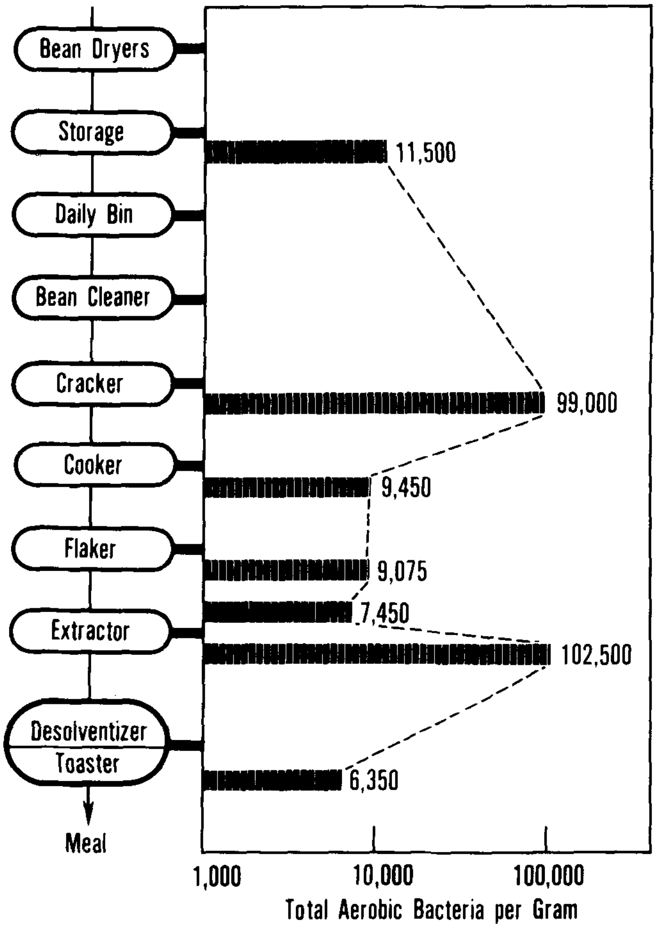

FIG. 2. Total plate count at various points in the SAO plant process.

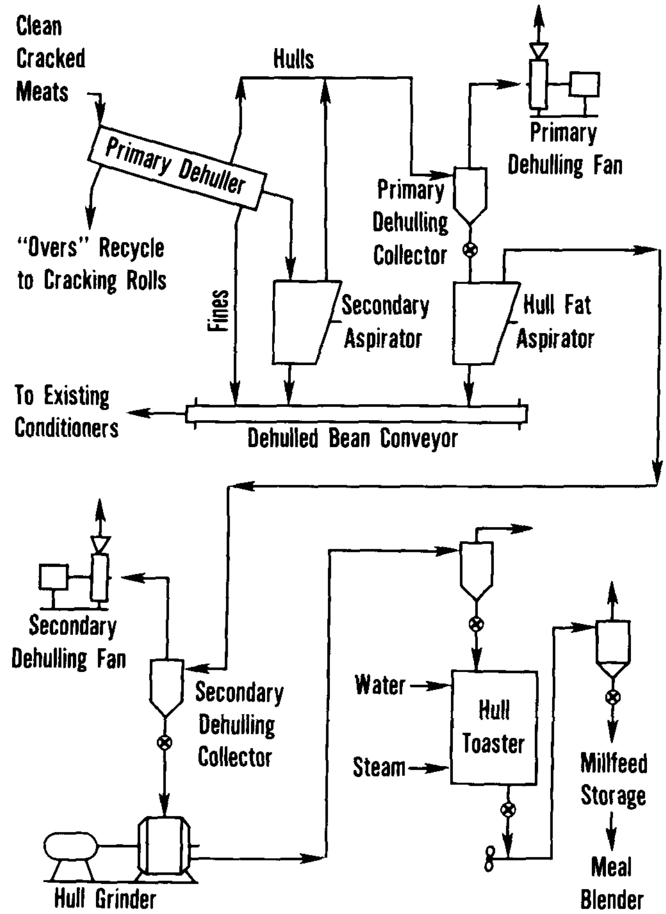

FIG. 3. Process modifications in preparation room.

existing daily bin of 250 metric tons capacity next to the preparation building. Beans then will be fed at a controlled rate of 150 MTD into the existing seed cleaner where foreign material and scalpings are separated, and fines leaving the bottom screen go to the "millstock" storage bin. Millstock consists of broken beans, chips, some trash, weed seeds, and hulls. A new secondary cleaner will be added to the production line to improve the degree of cleaning of the beans. When the millstock bin is full, edible protein production is suspended and the second cleaner and new dehulling equipment is bypassed. The millstock is then blended with whole beans in a ratio determined by experience and processed to animal feed as in the existing current operation.

Clean beans will pass through the existing cracking rolls and then to a dehulling system (new). In the primary dehuller, the cracked beans are first passed over a scalping deck where any smashed beans and large "eggshell" hulls, commonly called "waffles," are removed and sent back to the cracking rolls (see Fig. 3). The fine meats fall into the dehulled bean conveyor. The larger meats and hulls are aspirated for hull removal and then flow to the secondary aspirator for additional hull removal before the meats fall into the dehulled bean conveyor. The hulls are conveyed by the primary dehulling fan to the primary dehulling collector and then flow by gravity to the hull fat aspirator for recovery of additional meats.

The dehulled bean conveyor delivers all the meats to the dehulled bean elevator, which returns them to the existing cooker feed conveyor. The beans are then conditioned in the existing cookers and flaked in the existing flaking mills, and the flakes are sent to the extraction plant.

Hulls go to a new hull-grinding system and then are fed to a new cooker and hammermill for toasting and grinding before going to millfeed storage (Fig. 3). Millfeed will be blended later with defatted meal to produce 44% protein meal.

Extraction

The existing horizontal basket extractor can be used without modification; however, the Redler conveyor transferring hot flakes between buildings to the extractor should be steam traced, with insulation added to ensure that condensation does not occur.

Flash Desolventizing

Fundamental data for the flash desolventizing of soybeans extracted with hexane and aqueous alcohols were reported in the early 1960s (2-4). Commercial application of the process with equipment added for Protein Dispersibility Index (DPI) control is described by Milligan and Suriano (5). Specified range for the proposed soy flour is 55-70 PDI for use in the composite flours whose general utility is for breads and pastas.

The flash desolventizing system is capable of achieving the highest possible PDI at the upper end of the desired range. Protein denaturation rate is affected by moisture content, temperature, and time. In the flash system a dry dehydrating atmosphere prevails; the temperature of the flakes is no higher than the boiling point of the solvent for most of the period in the desolventizer, and the retention time in the system is only several seconds. These most favorable conditions result in least denaturation and highest PDI, as high as 85 if the flake feed to the unit has a PDI of

90. The system proposed is also capable of cooking these flakes to any desired value of PDI down to 20 (fully cooked) by simple alterations in processing conditions of temperature, moisture, and retention time. Thus, the system has complete flexibility for producing whatever PDI is required.

A flash desolventizing system is recommended to be installed in the extractor area near the present desolventizer-toaster (D-T). Figure 4 is a diagram of a flash desolventizer that is capable of producing desolventized flakes in any range of PDI. In the flash system, extracted spent flakes will be diverted from the existing conveyor to the D-T and fed through a flake feed lock into the flash desolventizer. The flash unit consists of a vapor superheater, a cyclone flake collector, and a vapor blower all interconnected with tubing. Part of the vapors leave the system at a point just beyond the blower discharge, passing through a vapor scrubber before entering a condenser (this is balanced with the amount of hexane entering with the feed). The condensate is recycled to the solvent water separator. Desolventized flakes leave the system through a rotary lock to a stripper and cooker. Here the residual solvent is further reduced and additional controlled cooking can be done to obtain the desired PDI value.

It is anticipated that the flash desolventizer system will be designed for 100 MTD based on a 150 MTD soybean feed to the plant to provide for maximum future production.

Edible Flour-Grit Grinding, Bagging, and Storage

Flakes from the flash desolventized system pass into the flour grinding system, which consists of a grinding mill-classifier combination connected with a product flour collector, milling exhauster, and bag dust filter. If grits are to be marketed, a coarse grit return from the mill classifier is sent to a special grit classifier and then to a sifter where it is sized. If little or no grits are produced, then grit stock is recycled to the original grinding mill and all product is ground to flour as specified at 100 or 200 mesh. Flour goes to a storage bin and then discharges to a flour packer machine. The above flour grinding system was tentatively designed for 50 MTD or one-half the flash desolventizer capacity, with space provided for an additional 50 MTD system.

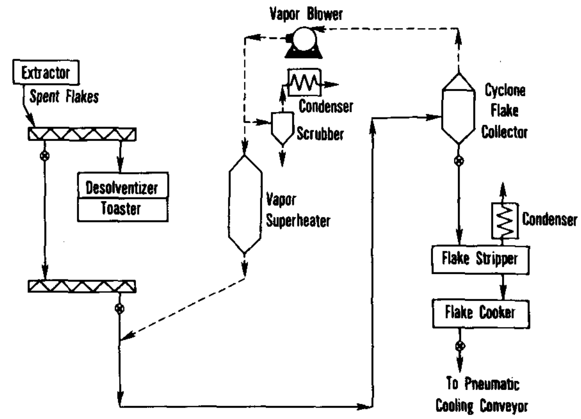

FIG. 4. Flow diagram of flash desolventizing system.

ACKNOWLEDGMENTS

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