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A Brief Technical Assessment

of the

SOYBEAN PROCESSING AND UTILIZATION PROJECT (SPU)

A Component of the Agricultural Research Project

(A collaborative effort of the Government of India and the U. S. Agency for International Development)

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EXECUTIVE SUMMARY

The Soybean Processing and Utilization (SPU) project has been a successful model for establishing collaborative research and development activities between Indian and US scientists. This work has focused on a high priority Indian agriculture/food problem which is also of interest to the United States. This project clearly accomplished its major objectives of establishing a well equipped research laboratory and pilot plant, training a cadre of scientists in soybean processing and utilization, and adapting/developing simple soybean processing technologies and equipment. The SPU has identified the following processes and products which have significant merit for further R & D and technology transfer in India:

* Production of low fat soy flour and edible oil from extrusion coupled with mechanical expelling

* Production of full fat soy flour, soy/cereal blends, and soy/pulse blends from extrusion cooking

* Production and popularization of food products from edible grade defatted soy meal from existing solvent extraction plants

* Use and promotion of soy flour in bakery products

* Production and promotion of soy paneer and soy based dairy analogs

There is now a window of opportunity to expand the use of high protein food products from soybeans to help meet the rapidly expanding markets for healthy and nutritious foods for all segments of Indian society. The private sector holds the key to the successful implementation of the processing, marketing, and use of soybeans in the domestic market. It is recommended that a follow-on "Institution to Institution" program be funded by USAID to assist the SPU staff aggressively carry out their operational research and technology transfer program with the private sector. SPU also will benefit from scientific/business exchanges with the US as it works to address critical research and development issues. SPU not only has the potential to play a lead role in training and transferring technology in India, but also throughout the Asian subcontinent.

PREFACE AND ACKNOWLEDGEMENTS

Dr. Nawab Ali, the SPU Project Director and his staff have published excellent quarterly and annual reports which contain well organized, comprehensive information about the project. A special updated report through November 1990 was prepared by the Project Director and is available as a supplement to this report.

I wish to acknowledge Dr. Nawab Ali and his SPU staff for candidly discussing all aspects of the project and making all printed information available. Thanks are also due to the Winrock staff in New Delhi and Washington for efficiently arranging logistics for this assignment.

SUBPROJECT DESCRIPTION

A. PURPOSE

(1) Statement of Purpose - The purpose of the SPU subproject is to strengthen the institutional capability of ICAR/SAUs to adapt/develop simple processing technologies and equipment which can make maximum use of soybean's unique quality of protein and edible oil. The overall goal is to produce low-cost food products adaptable to the Indian dietary patterns and to promote and transfer the technology through village/cottage level food industries.

(2) Linkage to Higher Goal - The SPU project supports the higher goal in the following ways:

> It relates to two high priority sectors of Indian agriculture which have not kept pace with the rapidly growing demand over the last several decades - the oilseed and pulse sector.
>
> It focuses on strengthening the research capabilities of Indian public institutions so that they can productively collaborate with agro-industries in the private sector (i.e. oil extraction, food processing, animal feed processing, processing machinery manufacturing) to expand the contribution of soybeans to solving the crisis in protein foods.

B. SPECIFIC OBJECTIVES

(1) Statement of Problems/Constraints/Opportunities - The green revolution brought dramatic increases in production of the major cereals, rice and wheat, in India but it has had little impact on oilseeds and pulses. Both oilseed and pulse production have not kept pace with population growth during the past two decades. As a result per capita consumption of edible oil in India is approximately half of the world average. Per capita consumption of pulses has actually declined from 60 g per day to 40 g per day. These shortages have serious impact on the Indian diet since most people are vegetarians and therefore must get a good share of their protein from pulses.

Soybeans, with 40 % protein and 20 % oil, were first promoted during the late 1960s as a commercial crop to provide a

supplemental source of protein food for the Indian diet. This effort, however, was not successful because of a lack of appropriate processing technology. Soybeans did not become a major commercial crop until the early 1980s when they were promoted for their use in helping meet the acute shortage of edible oil. GOI policy encouraged the construction of private, public and cooperative sector oil extraction plants and the export of the high protein meal to earn foreign exchange. The profitability of soybean processing was evident from the rapid increase in processing capacity. As a result of surplus processing capacity, the processing industry worked to increase soybean production by paying farmers high prices for their soybeans and by working with government research and extension programs to increase yield. As a result, during the past decade, soybean production has increased nearly five fold from .5 million metric tons to approximately 2.4 million metric tons. Approximately 1 million metric tons of soybean meal is now exported.

Neither whole soybeans nor high protein flour or food products from solvent extracted meal have become widely used in Indian diets. This applied research project was designed to develop technology which would lay the foundation for increasing the use of soy protein in foods in India.

(2) Descriptive Statement of Objectives - The SPU project goal was to establish a research program at the Central Institute of Agricultural Engineering (CIAE), Bhopal, M.P. and undertake research on adapting/developing processing technologies and equipment applicable for use in the home, village, and small scale industries. A second center at G. B. Pant Agricultural University, Pantnagar, U.P. was supported to provide graduate training in oilseed processing. Six program components were directed towards making the following products:

Component 1. Fullfat soy flour - The goal was to develop a simple process for making full fat soy flour. The first requirement was to thermally inactivate antinutritional factors, such as the trypsin inhibitor, and to prevent off flavor from lipoxygenase. Equipment was needed to dehull, dry, grind and mill the soybeans into flour. Methods were needed to evaluate the nutritional and utilization parameters for the flour and to set standards for the products.

Component 2. Dal (splits) - The goal was to design and develop equipment for dehulling and splitting whole soybeans to obtain dal. The process required that soybeans be tenderized and dried so that their appearance conformed to traditional dal both before and after cooking.

Component 3. Soy flour and other soy products from low-cost extrusion - The original goal was to develop a low-cost

cooker extruder to process soybeans into precooked fullfat flour and to establish product identity and nutritional standards. Additional goals were to develop equipment associated with pre and post extrusion processing activities.

Component 4. Low fat soy flour - The goal was to develop manual and bullock operated oil expellers which would remove approximately 75 percent of the oil and produce a low-fat soybean flour. Associated with this was the goal to design equipment to refine the oil and procedures to establish quality and nutrition standards for low-fat flour and to develop ways to use the flour in Indian food.

Component 5. Soy flour fortified baked products - The goal was to survey existing methods used by small bakeries for making bread and biscuits and design processes and equipment which could be used to prepare soy flour fortified baked goods. The goal was to develop standardized procedures for preparing soy fortified baked products.

Component 6. Fermented and coagulated soy products - The goal was to develop a simple process and equipment for making soybean coagulated products like soybean paneer (tofu) and for making soybean fermented products such as tempeh, miso, and natto. The goal included the establishment of quality and nutritional standards for these products.

Two additional components/objectives were to establish capabilities to develop and market the above products:

Component 7. Handling, storage, and packaging of whole soybeans and products - The goal was to establish appropriate systems technologies for handling, storing, and packaging whole soybeans and soy products. This included the identification of storage structures at the farm level, proper methods for handling soybeans, proper packaging materials for processed soy products, evaluation of quality characteristics of stored soybeans and determining the shelf-life of soy products.

Component 8. Training in the above aspects of processing and utilization - The training component had two thrusts. First was to provide short term training in the USA in specialized areas and the visit of American scientists or business people to work with SPU staff in India. Second was an academic thrust to support graduate training at the M.Sc., M.Tech. and Ph.D. level at G. B. Pant Agricultural University at Pantnagar, Uttar Pradesh.

C. INPUT/OUTPUT MATRICES BY OBJECTIVE

(1) Specification of Inputs and linked outputs - The SPU project has provided India with a well equipped research laboratory and pilot plant facility and a cadre of trained staff to conduct research and development activities on soybean processing and utilization. The facilities have indigenous equipment worth about Rs 2.1 million and imported equipment worth approximately $500,000. In spite of delays in obtaining equipment and completing the research laboratories and pilot plant, substantial progress in adapting/developing processes and products has been made to date.

* The project made a total of 17 different types of processing equipment and 11 different products.

* Two well attended national seminars were organized by SPU. One was on "Processing and Utilization of Soybean in India" and the other was on "Production and Utilization of Defatted Soy Meal".

* More than 60 scientific papers were published by SPU scientists in national and international journals.

* More than 100 enquiries have been received from potential entrepreneurs.

COMPONENT	INPUTS		LINKED OUTPUTS
(1) FULLFAT FLOUR	USA	Equipment - Insta Pro - Fitz mill Training Consultants - Love - Walker - Shukla Liaison to US Institutions and Industry	SMALL COMMERCIAL: * equipment developed includes - small blancher - manual destoner - manual dehuller - power dehuller - 3 types of dryers * improved local burr mill * quality standards developed * determined 3 mo shelf life * 100 kg/day system developed & feasibility study says - need Rs 70,000 investment - 30 % return on investment - 2 year pay back period MEDIUM SCALE COMMERCIAL: * demonstrated that Insta Pro extruder makes good fullfat product for food and feed
	---- GOI	---------- Facilities Staffing Equipment Graduate Training Liaison to Other Institutions and Industry	
(2) DAL	USA	Training	* not successful at developing a practical method for making dal from soybeans * demonstrated possibility of blending with other pulses and extruding or pressure cooking
	---- GOI	---------- Facilities Staffing Equipment	

COMPONENT	INPUTS		LINKED OUTPUTS
(3) EXTRUSION PRODUCTS	USA

COMPONENT	INPUTS		LINKED OUTPUTS
(5) SOY FORTIFIED BAKED PRODUCTS	USA	Equipment - extensograph - sheeter Training - AIB Consultants - Walker - Ranhotra	SMALL COMMERCIAL: * Process for making - 30% soy fortified biscuits - 18% soy fortified bread - 50% soy fortified cake * A feasibility study has been made for making 200 kg of biscuits per day
	---- GOI	---------- Facilities Staffing Equipment Liaison to Other Institutions	* Marketing soy fortified biscuits to M. P. Agro Industries

(6) COAGULATED AND FERMENTED PRODUCTS	USA	Equipment - Takai tofu plant Training Consultants - Wei - Demos Liaison to US Institutions and Industry	SMALL COMMERCIAL: * Process and equipment for 100 kg/day soy paneer plant developed * Tempeh was prepared using soy and gram blends * Modified methods for making soymilk, ice cream and yogurt were developed
	---- GOI	---------- Facilities Staffing Equipment	MEDIUM SCALE COMMERCIAL: * 50 kg/hr Takai plant made good quality soy paneer * Feasibility study showed the Takai plant to be profitable if proper market is developed

COMPONENT	INPUTS		LINKED OUTPUTS
(7) HANDLING STORAGE AND PACKAGING	USA

TECHNICAL ASSESSMENT

A. INPUT/OUTPUT PROGRESS BY OBJECTIVE

(1) Assessment of Inputs Provided (Appropriateness, Timeliness, and Quality)

COUNTRY/ITEM		APPROPRIATENESS	TIMELINESS	QUALITY
USA	EQUIPMENT	Good	Delayed due to internal AID regulations	Good but some problem in support for installation
	TRAINING	Good	Good but 21 man months unused because of 5 staff vacancies	Good
	CONSULTING	Good	Delayed due to late arrival of equipment and building	Good
	LINKAGE TO USA INSTITUTION	Good	Delays due to going through 3rd party	Good
GOI	FACILITIES	Good	Delays in construction but more than in original plan	Good
	EQUIPMENT	Good	Delay in getting expeller due to GOI procurement procedures.	Some were poor due to GOI procurement procedures
	STAFFING	Good	Delays in hiring some staff due to GOI hiring procedures	Good but difficulty in filling several scientific staff

TRAINING ACADEMIC	Good	Good	Good
LINKAGE TO INDIAN INSTITUTION	Good	Good	Good

(2) Assessment of Outputs Achieved (Some Qualitative Comments) - The following are some comments about the quality of the outputs and the relative importance to future application:

Component 1. Fullfat soy flour - Fullfat soy flour has been demonstrated to make good products when fortifying cereals. One can argue, however, that since India is so short of edible oil, more emphasis should be placed on using lowfat or defatted flour.

Component 2. Dal (splits) - Soy dal splits alone can not be used to replace traditional dals. There is some potential in blending low-cost soybean products with high-cost pulses.

Component 3. Soy flour and other soy products from low-cost extrusion - The Insta Pro 600, 2000, and 2500 extruders with capacities of processing approximately 600, 2000, and 2500 kg of soybeans per hr respectively, have great potential for producing fullfat soy flour and for pretreating soybeans prior to mechanical oil expelling so that up to 75 per cent of the oil is removed. Once the various extruders are matched with Indian made expellers and thoroughly tested, extrusion/ expelling may offer significant possibilities for processing soybeans grown in non conventional areas as well as for making specialty products in the main production area of Madhya Pradesh. Studies at INTSOY and several private companies in the US are promising. Due to delays in procuring the Indian expeller at SPU, tests will begin in early December.

Component 4. Low fat soy flour - The Insta Pro extruders coupled with Indian made expellers show great promise in extracting 75 percent of the oil and producing an excellent grade low fat soy meal that can be used for food and feed. Preliminary studies show that the low fat soy flour can be used in biscuits, bread, and chapatis.

Component 5. Soy flour fortified baked products - There is significant scope for fortifying cereals with various types of soy flour. Due to the large supply of defatted meal in the country, however, major efforts should be initiated in that area to complement the ongoing work on fullfat and lowfat flour.

Component 6. Fermented and coagulated soy products - Excellent quality, low cost soy paneer can be made from large commercial systems as well as from small units made from indigenous equipment. Feasibility studies show both systems can be profitable but the big challenge is to develop the markets. Soymilk and dairy analogs (ice cream and yogurt) appear to have potential if started on a small scale with low investment costs. Three large soymilk plants in India have had difficulty in becoming profitable due to large capital costs, expensive packaging, and broad distribution and marketing requirements.

Component 7. Handling, storage, and packaging of whole soybeans and products - Due to rapid advances in the Indian packaging industry there will likely be continued improvements in the quality of packaging materials and a reduction of packaging costs.

B. PROGRESS TOWARD OBJECTIVES

(1) Appropriateness of Objective Priorities - There is a growing awareness in India that the protein from soybean must play an increasingly important role in meeting urgent needs for protein foods in the domestic market. This awareness results from the highly visible successes of the soybean industry in Madhya Pradesh, and more recently in several other states. The rate of growth of the Indian soybean industry is on par with Brazil and Argentina, the worlds leaders. The profitability of the crop and its two major products have demonstrated proven economic benefits to producers, processors, retailers, and consumers of the oil. There is now a window of opportunity for SPU project to play a catalyzing role in popularizing the use of soy protein in Indian food and some of the technology will help expand the use in the poultry industry as well. Therefore this project has a very high priority.

(a) ICAR/SAU System: This research and development project now provides the ICAR system with the capabilities to respond effectively to this important national need. This type of project is appropriately placed with an ICAR institution in the center of the soybean producing area in Madhya Pradesh.

(b) Indian System: This project fits very well into the Indian system because it focuses on the adaptation/development of simple technology which can lead to productive gains in employment,

income, and nutritional well being.

(2) Importance of US Interests - This project has significant importance to the US for the following reasons:

(a) Current:

* There has been a strong historical linkage between the US and India in the founding of the research and development programs which lead to the commercial soybean industry in India and the popularizing of soy oil. This collaboration between Indian and US scientists and industry has been mutually beneficial in spite of the perceptions by some that it has created competition for the US.

* The US, as the world's major producer and exporter of soybeans, has a strong interest and program directed toward finding new markets for soybeans and soy products. India, with the world's second largest population, offers long term opportunities for expanding markets for soybean oil and protein products.

* The American Soybean Association (ASA) has an office and program in India to promote the use of soy products. Their goal is to continue to popularize soybean oil and encourage the development of local markets for Indian produced soybean meal.

(b) Future:

* US interests will expand as it is demonstrated that soy products can be successfully used in a wide array of Indian traditional foods and that equipment such as expanders and extruders can make the processing more efficient.

* Much like the primary role private industry has played in developing the Indian poultry industry, private industry will play the lead role in further development of the soybean industry. Since USAID is putting major emphasis on helping the private sector, they have an opportunity to support this development.

* US companies can benefit from the sale of processing equipment or develop joint ventures with Indian companies. Of special importance is extrusion technology has wide application in India and many other developing countries.

* The US is collaborating with India in the establishment of a national germplasm bank. The collection of wild soybeans in remote areas of north and northeast India will be of interest to US scientists. There should be a growing trend towards collaboration on genetic engineering in soybeans between US and Indian scientists.

* The ASA is exploring ways to expand its activities in India to assist in the expansion of the use of soybeans on the domestic market.

(3) US Role and Advantage in Cooperation - The US has the largest and strongest soybean research program in the world and is the center for training soybean scientists. Soybeans became a commercial crop in India under the collaborative effort of USAID supported University building programs in the 1960s. Many of India's original soybean scientists were trained in the US at that time and many US scientists were involved with the research and extension activities in India. The International Soybean Program (INTSOY) at the University of Illinois was a direct outgrowth of activities in India. INTSOY has been the world leader in coordinating soybean germplasm exchanges and more recently in conducting and coordinating collaborative research on small scale soybean processing technologies.

C. PROGRESS TOWARD PURPOSE

(1) Relevance

(a) ICAR/SAU System: ICAR has demonstrated its growing interest in post harvest technology by earmarking funds for new programs such as the SPU and for an Institute of Post Harvest Technology. This project demonstrates that ICAR can interface better with the soybean industry than the SAU system.

(b) Indian System: Soybeans are now recognized by both the GOI and several state governments as an essential part of meeting their edible oil needs. Many are now beginning to recognize the opportunity for increasing the use of soy protein.

(2) Mutuality of Interest

(a) Current: The US and India have a mutual interest in the soybean industry from an historical perspective, as well as an economic perspective. Although many US farmers may perceive that India is a competing producer of soybeans, when they study the situation they realize that the domestic soybean production has been the biggest driving force to popularize soy products.

(b) Future: The mutual interest in the soybean industry will expand because of the economic benefits to both countries arising from the increased use of soybean products to meet the food and feed needs of the domestic market. The market for US made extruders and Indian made expellers should expand rapidly as extrusion/expelling technology is popularized in a number of developing countries during the next decade.

(3) Follow-On Cooperation - The significant progress made in this project, the current status of the Indian soybean industry, and the mutual interest of the US and India, suggests that a strong follow-on cooperative project be implemented. The following general outline is recommended:

(a) SPU Project Needs: Now that the research facility and trained manpower are in place and the research program is in full swing, the focus of the next phase should be on the following:

* Operational research and technology transfer activities should include the set-up of demonstration or model plants in each of the processing/product areas. These demonstration plants will supplement the work in the pilot plant.

* Collaborative research and scientific exchanges in the following R & D areas

  - Production of low fat soy flour and edible oil from extrusion coupled with mechanical expellers

  - Production of full fat soy flour, soy/cereal blends, and soy/pulse blends from extrusion

  - Production and popularization of food products from edible grade defatted soy meal from existing solvent extraction plants

  - Use of soy flour in bakery products

  - Production and promotion of soy based dairy analogs and economic utilization of okara

(b) Proposed Institution to Institution Program: I propose that the USAID mission in Delhi provide a buy-in to INTSOY through the S & T Bureau to collaborate with SPU on the above areas. Some of the proposed activities would be as follows:

* **Scientific exchanges** in academic areas such as food science, food engineering, entrepreneurship, business management, economics, and marketing

* **Business exchanges** with people operating soy processing business in the US or other countries such as extrusion/expelling processing, tofu and soy milk processing, baking, and marketing.

* **Collaborative research** in critical areas listed above

* **Special training/promotion.** One promotion activity would be the joint sponsorship of an International Seminar on Soybean Processing and Utilization in Bhopal in November 1991 to showcase the SPU and the Indian soybean program. This could also be used to develop regional links in the Asian subcontinent.

A buy-in with a budget of $400,000 per year is proposed to be used in the following way:

Scientific Exchanges	$100,000
Business Exchanges	$100,000
Collaborative Research	$100,000
Special Training/Promotion	$400,000
TOTAL	$400,000

ANNEX I. ITINERARY FOLLOWED DURING THE COURSE OF THIS ASSESSMENT

NOV	15-16	USA to India	
	17-18	New Delhi	Winrock USAID ICAR
	19-22	Bhopal	SPU/CIAE MP Oilseed Federation
	23	Indore	National Research Center for Soybeans Soybean Processors Association of India
	24-29	New Delhi	Winrock USAID ICAR American Soybean Association Private Industry
	30	India to USA	

ANNEX 2. PERSONS CONTACTED DURING THE COURSE OF THIS ASSESSMENT.

NEW DELHI	USAID	John Becker	
		Surjan Singh	
	Winrock	Colin McClung	
		P. S. Srinivasin	
	ICAR	A. Alam	
	American Soybean Ass.	S. C. Singhal	
	Vegpro Ltd.	S. Rao	
BHOPAL	CIAE	N. S. L. Srivastava	Director
		Nawab Ali	Project Director
		A. P. Gandhi	Biochemist
		B. S. Bisht	Process Engineer
		S. D. Kulkarni	Process Engineer
		Jaswant Singh	Process Engineer
		R. T. Patil	Process Engineer
		Krishna Jha	Microbiologist
		K. C. Joshi	Biochemist
		P. C. Bargale	Process Engineer
		L. K. Sinha	Process Engineer
		S. K Khare	Biochemist
	M.P. Oil Federation	M. D. Tedic	Executive Director
INDORE	National Res. Center.	P. S. Bhatnagar,	Director for Soybeans
	Soybean Processors	G. A. Sulebele	Chief Executive Assoc. of India
	Prestige Feed Mills	Manmath Patni	Product Dev. Man.
	Premium Industries	Rajesh Agrawal	Director