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Subproject 1:

'BEAN PROCESSING AND UTILIZATIO

N COUNCIL OF AGRICULTURAL RESEARCH

AND

USAID/NEW DELHI

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January 1985

Subproject Outline

Title of Subproject: Soybean Processing and Utilization

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SOYBEAN PROCESSING AND UTILIZATION

AGRICULTURAL RESEARCH AND DEVELOPMENT

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I. SUMMARY

The proposed subproject in research and development for soybean processing and utilization is to be conducted at the Central Institute of Agricultural Engineering, Bhopal (M.P.) and G.B. Pant University of Agriculture and Technology Pantnagar (U.P.). This program supports and furthers objectives of the All India Coordinated Research Project on Soybean, and the All India Coordinated Project on Post Harvest Technology, Indian Council of Agricultural Research (ICAR). The subproject design focuses on applied research in developing simple processes and equipment to make soybeans into low-cost food products adaptable to the Indian dietary pattern. Processing technologies are to be suitable for home, village, and small industry level operations.

The food products include full-fat soy flour, low-fat soy flour, extrusion cooked soy flour (low-cost extrusion technology), soy-supplemented baked foods, soybean cheese (paneer) and fermented soybean foods. Improved storage and packaging methods for soybeans (farm level) and processed soy food products are to be investigated.

New and modified processing systems are to serve as a small rural industry. Increased soybean consumption and the existence of rural processing units benefits the small farmer and serves both the rural and urban population.

This research addresses itself to the improvement in the nutritional adequacy of the basic Indian diet. It also aims at generating qualified personnel in oilseed processing utilization, especially Soybean.

II. SUBPROJECT DEFINITION

Soybean processing and utilization research activities will focus on the development of processes and equipment for production of suitable soybean products available to the consumer at a low cost. Appropriate research is needed to develop methods for processing soybeans which relate

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* The staff at CIAE were also invloved in the preparation of this report.

specifically to home and village level operation. The utilization of soybeans in the home and village offers an ideal approach for improving the diet of those in need of a better food consumption pattern.

Specific processing units based on simple soybean technologies will be designed to operate at the domestic (home), village (community), and small industry levels. The identification, development and testing of processing technologies encompasses the postharvest technology concept of handling, storage, processing, packaging, marketing and utilization. The reduction of soybean postharvest losses by improved processing technologies will benefit both the small farmer and the rural sector of the population.

An Operational Research Program will address the establishment of the pilot plant unit based on developed proesses and equipment (prototypes) in a selected village. This operational unit will be based on the research model established at the CIAE.

A supportive training program in oilseed processing and utilization will address to generation of suitable manpower for research and developmental activities in this area.

A. Objectives

Subproject: Processing and Utilization of Soybeans

The basic objective of the subproject is to maximize the use of soybeans as a food source and improve soybean processing and utilization with particular reference to the low income segment of the society. Research activities, therefore, are geared to the development of simple and adaptable soybean processes and equipment, and subsequent technology transfer to the rural population at the home, village and small industry level.

The subproject also aims at the dissemination of proven technologies to consumers and processors at various levels of operation. The problems associated with the processing and utilization of soybeans adaptable to the home and village level is attributable to: (a) the development of an off-flavor (beany flavor) from improper soybean processing; (b) the presence of trypsin inhibitors in unprocessed soybeans; (c) the presence of flatulence factors (formation of gastrointenstinal gas) in soybeans; (d) the poor cooking quality of soybeans associated with hardness and subsequent increased cooking time; (e) the lack of simple processing methods of soybeans at the home and village level; (f) the unavailability of low-cost equipment for processing soybeans at the home and village level; (g) the lack of pilot plant facilities for promoting soybean processing at the small industry level; (h) the lack of information on proper packaging and storage methods for soybean products.

B. Rationale

India's population is predominantly rural and its economy is based on agriculture. About eighty percent of thetotal population (approximately 680 million) lives in rural villages. Although some significant gains in agricultural production were made during the past two decades, the per capita availability of food did not increase materially due to population growth.

The average Indian diet consists primarily of cereals and pulses contributing to about 80 percent of the total calorie intake. Pulses (legumes, grams) which constitute about 10 percent of the food grains consumption, are the major source of protein in the cereal based diet. The production of pulses during the last three decades has remained static at about 11 million tons annually. Consequently, the per capita consumption of pulses has progressively declined by about 30 percent. The common Indian diet is also deficient in fats.

The nutritional potential of soybean in this context are considerable. Soybeans contain about 40 percent protein and 20 percent oil, characteristic of a food product having a high protein-energy ratio. The high quality of soy protein is illustrated by its content of all the essential amino acids with the exception of the sulphur-containing (methionine) amino acid. This imbalance is adequately offset in a traditional cereal-based mixed diet. Supplementation of the cereal-based diet with soy protein gives an amino acid complementation which results in increased protein quality and quantity approaching that of animal protein. Soybean oil contains a large amount of unsaturated essential fatty acids. In addition to its high food value, soybeans are one of the least expensive sources of protein.

An interdisciplinary coordinated research project on soybeans was launched in 1967 by the Indian Council of Agricultural Research (ICAR). Studies were conducted with the cooperation of the University of Illinois (USA), USAID, and ICAR mainly at Pantnagar and Jabalpur. The main objectives and research areas of the Coordinated Research Project on Soybeans were: (1) Collection, evaluation, and maintenance of germplasm for direct and indirect use for different agro-climatic zones of the country; (2) Evolution of high yielding varieties which are disease-resistant; (3) Development of early maturing varieties for companion cropping with cotton and maize; (4) Incorporation of good germination and longer storability characteristics from indigenous black variety and exotic germplasm; (5) Evaluating input demands at different stages of plant growth; (6) Develop planting, harvesting, and threshing machinery; (7) Economic analyses of soybean production; and (8) Postharvest technology including processing, utilization, product development, and marketing.

The overall cultivated land area of soybeans in India in 1971 was 40,000 hectares giving a total production of 32,000 MT. The acreage as well as production of soybeans under the centrally sponsored scheme for Soybean Developement in 1980-81 was about 743,000 hectares and 670,000 MT, respectively. The main areas of soybean cultivation are in Madhya Pradesh (81%) and Uttar Pradesh (18%). The targetted acreage of soybeans for 1982-83 is 900,000 hectares.

Soybean cultivation in Madhya Pradesh was introduced during 1971-72 under the centrally sponsored scheme for Soybean Development. The initial land area under soybeans of 2,000 hectares has increased to about 600,000 hectares in 1980-81. The major expansion in soybean cultivation has been in Madhya Pradesh. It is projected that the land area will increase three fold to 1.8 million hectares in 1985-86.

Soybean cultivation does well in the dry farming area of Madhya Pradesh where irrigation facilities are limited. The most important districts for cultivation are Ujjain, Dewas, Shajapur and Mandsaurin Ujjain Division; Betul, Sehore, Raisen and Vidisha in Bhopal Division, and Indore and Dhar in Indore Division and Hoshangabad. Soybeans grow well in the light to heavy clay soils and are very adaptable to both moisture stress and excessive moisture conditions during growth. It is cultivated during the kharif (rainy) season.

Although soybeans were introduced in India primarily as a protein food source, this main objective is not being met. A status paper on An Overview of Soybean in India (Project Coordinator, All India Coordinated Research Project on Soybean - ICAR, 1981) indicates that there is a lack of research in the area of soybean product development and utilization as a food source. Emphasis on soybean utilization in India has been to augment edible oil production. Today more than 100 solvent extraction plants for oil exist and those processing soybeans into oil and animal feed (soybean cake) are increasing. The utilization of soybeans as a food product of high protein and related nutritional value is not being addressed.

TABLE 1

SOYBEAN PRODUCTION IN INDIA

1980-81

STATE	Area (Hectares)	Production (MT)
Madhya Pradesh	500,000	540,000
Uttar Pradesh	132,000	120,000
Bihar	5,000	4,500
Himachal Pradesh	4,000	3,700
Rajasthan	2,000	1,800
TOTAL	43,000	670,000

Source: All India Coordinated Research Project on Soybean Production (Indian Council of Agricultural Research)

It has been established at the laboratory level that soybeans can be used in various Indian food preparations (G.P. Pant University of Agriculture and Technology, Pantnagar; J.N.K.V.V., Jabalpur and the University of Agricultural Sciences, Bangalore). The early development of soybean recipes, however, has not addressed a wider usage of soybeans by the development of related equipment and processes to enable the establishment of a small, village soybean processing industry. This will directly benefit the rural people.

A pilot level production of soy milk has been established based on large-scale soybean processing technology at the G.B. Pant University of Agriculture and Technology. In addition, textured soybean products based on defatted soy flour are being commercially manufactured and marketed in India. These products, however, conform basically to a limited pattern of utilization more suited to higher income groups. They are quite expensive and, therefore, beyond the reach of low-income groups. It is necessary that soybean products utilizable in the Indian food pattern become available at a lower price commensurable with the purchasing power of an average Indian.

Overall future research needed is a launching of the development of appropriate processing technologies for the rural area, product development, utilization and marketing. Large scale utilization of soybeans in the rural areas is dependent upon both an increased awareness of the nutritional benefits of soybeans and appropriate product formulation and development.

A concentrated effort has to be made to develop processing technologies for the effective utilization of soybeans as a human food particularly among the lower economic sectors. Major emphasis of this subproject will be on the development of processes and equipment for the utilization of soybeans at the home and village level and the development of a rural small industry. The establishment of village operational units in soy processing to obtain value-added products is directed to benefit the small farmer and the village community. The production of soy flour and other soy products would constitute a rural industry providing increased income and employment for the rural population. A rural soybean processing plant having a daily output of 1,000 kg would employ 15-20 people.

The production of soy flour is more involved than the production of wheat or sorghum flour. Indian women have requisite skills to carry out the necessary processing oprations and have full-fat flour not only for their own consumption but also available for sale to the urban people.

The development and transfer of soy processing technology from the small production unit to the organized industry (pilot plant) stage would further the use of soybeans as a protein-rich human food. The potential of soybeans as a food crop is realized when processing technologies and facilities are available which produce soybean products that are adapted to the food habits and market conditions in India.

The availability of low-cost processed soybean products, such as full-fat soy flour and others could increase the nutritional adequacy of an otherwise inadequate diet of the rural poor. Soy protein can replace animal protein in human diets. It is estimated that the per capita consumption of protein per day is 30-50 gm with about 10 percent being derived from animal sources. The calorie intake averages 1,700 - 2,000 per day. Average figures do not reflect the apparent protein and calorie deficiencies in the particularly vulnerable groups, i.e. preschool children and pregnant and lactating women, both rural and urban. The lack of dietary protein is the most likely factor that limits growth in children. Recommended daily allowances for protein and calories are not met in a large sector of the rural population.

The supplementation of wheat flour with 10 percent soy flour in traditional Indian foods could significantly increase the dietary protein intake. Wheat flour utilization, primarily for chappatis, ranges from 40 - 60 kg monthly in the rural home. The utilization of soybean flour at a level of 4 - 6 kg monthly could significantly increase the demand for soybeans. This would represent a utilization of over 50,000 metric tons/month of soy flour in the rural areas of Madhya Pradesh. This population would increase its dietary protein intake by 30 percent.

The constraints to the acceptability of soybeans as a food are largely attributable to its involved processing, flavor, cooking quality and physical characteristics as compared to traditional foods. In addition, there is a need for processing procedures which easily eliminate anti-nutritional factors. The development of simple soybean processing technologies is needed. Research should involve the study of specific physical and organoleptic properties which are desirable in traditional Indian foods. The development of soybean products which posses similar properties, therefore, would increase the acceptance of soybeans as a food.

The distribution of soy products is for both rural and urban markets. The soybean food products would be for India's own food requirements.

III. STRATEGY - COMPONENT ACTIVITIES

Subproject Components:

1. The development of processes and equipment for full-fat soybean flour applicable to the home, village, and small industry level.

2. The development of processes and equipment to obtain dal (splits) from soybeans applicable to the home, village, and small industry level.

3. The development of low-cost extrusion cooking processes and equipment for soybean flour and other soy products applicable to the small industry level.

4. The development of processes and equipment for preparing low fat soybean flour applicable to the village and small industry level.

5. The development of processes and equipment for soy flour supplemented baked products applicable to the small industry level.

6. The development of processes and equipment for fermented and coagulated soy-based products applicable to the home, village and small industry level.

7. The establishment of appropriate systems technologies for handling, storage, and packaging of whole soybeans and soy products.

8. Supportive training program in oilseed processing and utilization.

The soybean processing and utilization subproject has a five-year program plan. To implement the project components and objectives effectively, the Central Institute of Agricultural Engineering (CIAE), will be responsible for conducting the research activities in soybean processing and utilization. Some of the available scientific and technical staff, having background in Soybean Processing as well as suitable laboratories, and equipment will be transferred to this subproject. Some analytical equipment, small scale processing equipment, and pilot plant processing equipment is needed. A number of the present scientific staff have been involved in initial soybean processing studies. Additional staff will be needed in the area of process engineering, cereal and food technology, chemical engineering and food chemistry. Short-term training is needed to train scientists in specific areas of soybean processing, soybean food product development, nutritional evaluation of soybean foods, low-cost extrusion cooking technology, and biochemical factors associated with soybean food uses.

Based on existing technologies and the traditional basic foods in the Indian diet, priority is given to the process development of full-fat soybean flour and a dal (splits) from soybeans. In addition, early investigation on low-cost extrusion technology is needed for the developmental research on soybean flours an other soy products.

The subproject has the basic components of applied, adaptive, and operational research geared to the dissemination of information and the transfer of technology to consumers and processors for various levels of operation. Certain activities of basic research related to specific processes and use of soybeans are involved.

Realizing the potential of soybeans, the Indian Council of Agricultural Research (ICAR) initiated the "All India Coordinated Research (ICAR) Project on Soybeans" in 1967. This research project lays emphasis on developing varieties suitable for different regions. The soybean processing and utilization research activities be complementary to these efforts and thus result in an integrated approach involving production, harvesting, storage and marketing in promoting soybeans as a food crop in India. The Central Government in conducting a centrally-sponsored scheme for the development of soybeans with the aim of increasing the acreage and yields under cultivation. The target area for soybean production in 1982-83 is 640,000 hectares in Madhya Pradesh which is over 80 percent of the soybean production area. The establishment of a reasearch program in soybean processing and utilization at the CIAE would effectively meet the objectives of the project.

Research linkages, therefore, would be with the All-India Coordinated Research Project in Soybeans as well as the All-India Coordinated Scheme on Postharvest Technology. The CIAE will liaise with the Madhya Pradesh Seed and Farm Corporation and the Madhya Pradesh Oilseed Cooperative Federation.

The overall research program will include the processing of whole soybeans into full-fat soy flour. The utilization full-fat soybean flour will be supplementing traditional chappatis and other foods at the home level. The preparation of soy-supplemented baked foods will concentrate on, but not be limited to, Indian style bread and biscuits at the small industry level.

An investigation will be conducted on developing processes for soybean curd and fermented soy products from both whole soybeans and full-fat soybean flour at home, village, and small industry level.

The development of fermented soybean foods should increase soybean consumption since the oriental utilization pattern of soybeans can complement traditional Indian foods in several regions.

The process for low-fat soybean flour will be studied with product application to baked foods.

Low cost extrusion cooking technology will be studied for processing whole soybeans into precooked full-fat soy flour. Related equipment will be designed to fit the scheme of village level processing with further application to small industry.

IV. SUBPROJECT IMPLEMENTATION

The overall implementation of the subproject shall be coordinated by the Deputy Director General, for Soils/Agronomy and Agricultural Engineering ICAR. A Coordination Committee consisting of six members to continuously monitor and evaluate the project is as follows:

1.	Deputy Director-General - ICAR (S.A.E.)	Chairman
2.	Assistant Director General (Agr. Engineering)	Member
3.	Director, CIAE, Bhopal	Member
4.	Project Coordinator - ICAR All India Coordinated Scheme on Soybean Production	Member
5.	Project Coordinator - ICAR All India Cooridinated Scheme on Postharvest Technology	Member
6.	Project Director - Soybean Processing Utilization Scheme, CIAE, Bhopal	Member-Secretary

Soybean Processing and Utilization

Research in process and equipment development and the transfer of technology will be conducted by project staff at the CIAE. The Director of CIAE is responsible for the Center. However, the Project Director will organize and implement the technical program including equipment procurement, building construction, and setting up of laboratory facilities. The Agricultural Scientist Recruitment Board (ASRB) of the ICAR will recruit the scientific staff, whereas the technical, administrative, and supporting staff will be recruited by the Director CIAE and the Project Director.

Collaborating Bodies

The exchange of technical information will be supported through the identified universities, institutions, and organizations as follows:

1. University of Illinois, Champaign - Urbana Dept. of Food Science, Dept. of Agricultural Engineering, Dept. of Foods and Nutrition and INTSOY - International Soybean Program.

ii. Colorado State University, Fort Collins, Colorado Dept. of Agricultural Engineering and Dept. of Nutrition.

iii. USDA Laboratory, Peoria, Illinois (Northern Regional Lab).

iv. Kansas State University, Manhattan, Kansas Food and Feed Grain Institute and Dept. of Grain Science and Industry.

v. University of Minnesota, St. Paul, Minnesota Dept. of Food Science and Dept. of Biochemistry.

vi. School of Packaging, Michigan State University, St. Joseph.

vii. All India Postharvest Technology Scheme, (ICAR).

viii. All India Coordinated Scheme on Soybean Production (ICAR).

It is proposed that product evaluation and acceptance studies be conducted in coordination with the department of Agriculture and the Department of Food with a view to disseminating new technologies. This work would be included under existing training program for women at Agricultural Science Centers. Earlier programs have included the utilization of soybean in daily diets and the preparation of different dishes from soy flour.

Subproject implementation would be further aided by the procurement of a photocopier machine to facilitate the preparation and distribution of reports. In addition, the library facilities and overall research activities at CIAE would be enhanced by the procurement of microfilm reader, microfilms of technical articles and theses on related issues in soybean processing and utilization, and audio-visual aids including a camera, slide projector, and film projector. It is proposed that the procurement of technical books and subscriptions to scientific journals be included in the subproject. Specific scientific journals include Cereal Chemistry, Soybean Bluebook, Journal of Food Science, Cereal World Foods, Baker's Digest, Journal of Milling, Journal of Nutrition, Journal of American Dietetic Association, Food Engineering, Food Product Development, and Transactions of the American Society of Agricultural Engineering. The procurement of "Soybeans-Chemistry and Technology" by Smith and Circle, Vols. I and II, and "Soybeans as a Food Source" by Wolf in sufficient quantity for distribution among scientific personnel is needed. Back volumes of journals containing articles related to soybean processing and utilization should also be included.

The CIAE and scientific staff on the soybean processing and utilization subproject will be responsible for implementing operational research programs. This will be based on the developed processes, equipment (prototypes), and systems identified under the subproject research program. A research model for one component is to be established in one selected village. A different village can be used for each component or one village can be used for several components. The subproject evaluation committee (end of year 2) will determine the feasibility of establishing the village pilot plant based on readiness and suitablity of the researched processes and equipment.

The operational research concept focuses on field evaluation, testing and demonstration of new technologies at the village level. This relates to the rural home, rural village, and rural-based small industry. The utilization of soybeans is promoted by developing processes to obtain value-added products. Improved soybean utilization is realized by establishing storage and packaging methods which minimize losses. The potential for increased rural employment exists. The operational research program can illustrate constraints to the model unit in the area of technology (process, equipment, systems) and management.

V. PLAN OF WORK

Component Objectives

1. To promote the use of soybeans as a food source for the rural population by adapting simple utilization technology to produce acceptable soybean foods.

2. To develop and adopt value added processes, equipment, and systems appropriate to levels of domestic operation, village level and small industry.

3. To design, establish, and test pilot plant operations to produce processed soybean products, namely, full-fat soy flour, low-fat soy flour, fermented, and coagulated soy foods.

4. To improve the handling and storage of whole soybeans and processed soy products to minimize postharvest losses.

5. To investigate various packaging materials for improving the keeping qualities of processed soy food products.

6. To develop manpower resource to propagate research and development in this area.

Soybean processing and Utilization research activities will span a five-year period. The plan of work is illustrated in five phases of program development as follows:

Phase I

Staff recruitment, personnel training, equipment procurement, building construction, collection of information, and generation of knowledge pool related to technologies of handling, storage, processing, and utilization of soybeans as a food. (Year 1)

Phase II

Identification and development of processing technologies and related equipment for soybean processing at the home and village level. Establishment of the experimental design for specific research areas relating to soybean food uses. (Year 2)

Phase III

Testing of processing technologies at CIAE (home, village, and small industry level), system and product development research, product evaluation - quality control, acceptance. Linkage with the developmental organizations - Department of Agriculture and Department of Food. (Years 3-5)

Phase IV

Preparation of techno-economic feasibility, soybean product marketing operational research in food uses. Linkage with the developmental organizations - Department of Agriculture and Department of Food. (Year 4-5)

Phase V (Operational Research)

Technology transfer to the small industry (pilot plant) level, processing systems, and equipment development; quality control, product standards. (Years 4-5)

The development of technologies for processing soybean foods is directed at the elimination of anti-nutritional factors (trypsin inhibitors), elimination of off-flavor development, improved functional properties (soybean flour) for traditional food uses, ease of preparation (whole soybeans), improved appearance, and improved storage.

Component 1

The development of processes and equipment for full-fat soybean flour applicable to the home, village and small industry level.

Soybeans are not being consumed in India as a protein food to supplement the diet. Soybean research activities conducted under the ICAR "All India Coordinated Research Project on Soybeans" has emphasized the development of varieties suitable for different regions and the study of related diseases, seed production, plant protection, and extension in soybean production. A soybean extension project which was initiated in 1974 by a private enterprise in collaboration with Pantnagar University focused on the commercial production of full-fat soybean flour on a large scale. Overall, very little work has been done on the development of simple processes and equipment for processing soybeans into full-fat flour at the home and village level. The subsequent establishment of small soybean flour processing industries for both urban and rural needs has not received attention.

When a rapid increase in soybean production and supply is possible, the processing and marketing of relatively unrefined soy flour is preferable. This could create a general demand for the product in low-income groups.

One of the critical constraints to the consumption of soybeans is attributable to the poor cooking quality of soybeans associated with hardness and increased cooking time. In addition, the development of an off-flavor (beany flavor) due to the presence of an enzyme in raw soybeans is a prime deterrent to its food use. The presence of antinutritional factors in raw soybeans, primarily trypsin inhibitors, results in decreased protein digestibility and utilization.

The development of simple processes and equipment for full-fat soybean flour would be a practical and suitable means for promoting soybean consumption. Full-fat soy flour contains about 40% protein. It can be used in the preparation of traditional chappatis. Investigations in India have shown that 10% full-fat soy flour can be used in place of wheat flour to make accaptable chappatis. The protein quality and quantity is improved.

The CIAE has initiated research in developing a low-cost technology enabling farmers to undertake the production of soyflour in the soybean-growing regions. Further research is needed to develop a standardized procedure and related equipment. The establishment of a small industry based on processing research would promote the consumption of soybeans at both the rural and urban level.

Soybeans are a major crop in the United States. Specific university centers, and institutes in the U.S. have ongoing research programs in soybean processing, soybean food uses, nutritional value of soybean foods, and soybean food product development. Research in processing parameters related to the nutritional quality of soy

B. Personnel Levels (A-available, N-new)

Scientist-in-charge

(A)	Scientist S-3 Process Engineer	(50%)
(A)	Scientist S-2 Biochemist/Microbiology	(50%)
(A)	Scientist S-1 Cereal Technology/Food Technology	(50%)
(N)	Scientist S-3 Food Chemist/Biochemist/Cereal Technology	(50%)
(N)	Scientist S-2 Food and Nutrition/Home Science	(50%)
(A)	Senior Technician T-4 Process Engineer	(20%)
(N)	Senior Technician T-6 Home Science/Nutrition	(50%)
(A)	Senior Technician T-4 Biochemist	(25%)

Training Programs

(A)	Scientist S-3 Year 1 3 months	University of Illinois Dept. of Food Science Soybean food uses, short course
(A)	Scientist S-2 Biochemist/ Microbiology Year 1 5 months	University of Minnesota Dept. of Biochemistry & Dept. of Food Science Study Program: soybean proteins; nutritional value; analytical methods
(N)	Scientist S-2 Food & Nutrition/ Home Science Year 2 5 months	University of Illinois Dept. of Food Science, Dept. of Foods & Nutrition - Course Program: organoleptic evaluation of soy products.
(A)	Scientist S-1 Cereal Technology/ Food Technology Year 2 3 months	University of Illinois Dept. of Food Science Soybean food uses, short course.
(N)	Scientist S-3 Food Chemist/ Biochemist Cereal Technology Year 2 3 months	USDA Lab., Peoria, Illinois Research program: Soybean processing; nutritional evaluation of soybean products.

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Training programs would be in conjunction with components 2, 4, 5, 6

Equipment

Year 1	$	Rs
Top-pan electronic balance		22,500
Heavy duty hot air oven (2)		30,000
Automatic fat analyser	10,000	
Automatic protein analyser	10,000	
Refrigerators (2)		20,000
Lab. cracking mill	2,000	
Hammer mill		15,000
Dehuller		15,000
Hand grinder		2,000
Flour sifter (lab)	1,000	
Instron	80,000	
Vacuum oven		10,000
Potentiometric titration apparatus		12,000
Voltage stabilizers (4)		20,000
Cleaner/separators (2)		10,000
Graders (2)		10,000
Triple beam balances (2)		5,000
Muffle furnace		9,000
Lab centrifuge (refrigerated)		50,000
Bomb calorimeter		10,000
Steam jacketed kettle		20,000
Total Year 1	$ 103,000	Rs 260,500

Year 2

Lab. pin mill	10,000	
Alpine sieve analyser	10,000	
Perforated disc mill		20,000
P.O. pump with variable speed		20,000
Rotary vacuum pump		15,000
Workshop tools and equipment		120,000
Animal house facility		90,000
Supplies (prototype equipment)		700,000
Voltmeters (2)	2,000	
Wattmeters (3)		4,500
Rotometers (2)		5,000
Potentiometers (2)		15,000
Stroboscope		10,000
Transformer (2)		10,000
Electrical motors/engines (5)		15,000

Electrical motors/starters (5)		2,500
Chlorination plant		10,000
Water softening plant		15,000
Portable platform scale		20,000
Timers (10)		15,000
Air compressor		15,000
Gas liquid chromatography		100,000
Atomic absorption spectro-photometer	22,000	
Air conditioners (4)		60,000
Total Year 2	$ 44,000	Rs 1,262,000
Year 3		
Packager	12,000	
Heat sealing machine		20,000
Variable speed motors (2)		25,000
Stainless steel packaging table (2)		20,000
Package belt conveyors (2)		20,000
Total Year 3	$ 12,000	Rs 85,000
GRAND TOTAL	$ 159,000	Rs 1,607,500

E. Consulting Services

USDA Northern Regional Lab, Peoria, Illinois. Soybean Processing Specialist: Soybean flours, food products and their nutritional evaluation. Year 1 - 1 month.

University of Illinois, Urbana, Illinois. INTSOY: Dept. of Food Science - Soybean Processing Specialist: Soybean flours and food products. Year 2 - 1 month.

Kansas State University - Dept. of Grain Science: Milling Technologist. Year 1 - 1 month. Year 3 - 1 month.

Consultation would be provided in conjunction with components 1, 2, 3, and 4.

F. Principal Reports, Reviews and Evaluation

The subproject will be reviewed and evaluated annually. Yearly subproject reports will be prepared and included in the CIAE annual report. Component research results will be published in appropriate journals.

G. End of Subproject Status

1. The availability of simple equipment to process soybeans into full-fat soy flour at the home and village level.

2. The establishment of a processing model for a small industry to process full-fat soy flour to serve both the rural and urban area.

3. The promotion of soybean consumption by facilitating the utilization of soybeans in the form of full-fat soy flour.

4. The establishment of improved processing methods for a full-fat soybean flour free of anti-nutritional factors and off-flavors.

5. The use of full-fat soybean flour in the regular diet of small farmers in the rural area.

6. Increased demand for soybeans and increased income to small farmers undertaking full-fat soybean flour processing.

All objectives should be met by the end of the subproject. Additional work under an operational research program will be needed in the establishment of the small industrial soybean flour processing unit at the village level. Further work will be needed in marketing and the economic feasibility of the processing unit.

COMPONENT 1

FULL-FAT SOYBEAN FLOUR

ITEM	YEAR 1 $	YEAR 1 Rs	YEAR 2 $	YEAR 2 Rs	YEAR 3 $	YEAR 3 Rs	YEAR 4 $	YEAR 4 Rs	YEAR 5 $	YEAR 5 Rs	TOTAL $	TOTAL Rs
Training												
U.S.	40,000		55,000								95,000	
India												
Workshops and Conferences												
Consulting	15,000		15,000		15,000				15,000		60,000	
Research Equipment												
U.S.	139,050		65,340		19,440						223,830	
India		260,500		1,388,200		102,000						1,750,700
Maintenance a/		237,500		602,260		648,580		648,580		648,580		2,785,500
Facilities		203,026		8,740		8,740		8,740		8,740		237,986
Office Equipment and Supplies		42,860		28,570		14,286		14,286		7,142		107,144
Maintenance b/		4,286		7,142		8,572		10,000		10,714		40,714
Operational Research								128,570		64,290		192,860
Vehicles												
India												
Maintenance c/												
Staff												
Present		42,800		44,312		45,830		47,340		48,862		229,144
New		36,500		37,710		38,930		40,140		41,360		194,640
In-country travel		7,145		7,145		7,145		7,145		7,145		35,725
TOTAL	194,050	834,617	135,340	2,124,079	34,440	874,083		904,801	15,000	836,833	378,830	5,574,413

a/ Includes spare parts, installations and fitting
b/ Includes recurring expenses.
c/ Includes recurring expenses.

Component 2

The development of processes and equipment to obtain dal (splits) from soybeans applicable to the home, village and small industry level.

The average Indian diet consists primarily of cereals and pulses. The latter constitute 10% of the food grain consumption. Dal is the term used for both dry dehulled split pulses and the gruel-type of food made from the pulses.

Pulses contain about 25-30% protein as compared to the 0% protein in soybeans. Since dal is a basic staple in the traditional Indian diet, the development of processes and equipment to prepare a soybean dal would be a positive means of increasing the consumption of soybeans in the urban and rural sector. The nutritional benefits of increased dietary protein from a locally-available food crop is apparent. The initial development of home and village processes for soybean dal would be the forerunner of establishing a small soybean dal processing industry.

Although various large dal milling companies exist in India, the process used for Indian lugumes (gram) is neither standardized nor efficient in regard to hull removal and product yield. Milling losses are about 20% and only 80% of the hull is removed. It is necessary that complete hull removal and cracking into uniform splits be obtained.

The major constraints to soybean dal processing would be efficient hull removal and soybean tenderization. The dehulling process would have to consider pre-treatment processes which would aid in hull removal while inhibiting off-flavor development. The elimination of trypsin inhibitors is an additional factor which would be addressed during pre-treatment processes for soybean tenderization. Indigenous dals yield a paste-type product when boiled. Processing parameters for developing a soybean dal must consider this quality factor. A reduction in cooking time is equally important.

Some studies have been conducted in soybean tenderization at the Northern Regional Laboratories, Peoria, Illinois, and at the University of Illinois, Urbana. Early studies indicated that soybean dal was preferred at a very soft texture. The obtention of paste-like soybean dal, however, needs further investigation.

A study on soybean dal was conducted at G. B. Pant University, Pantanagar. This work illustrated the potential for processing a soybean dal based on a proper method for tenderizing soybeans. Further work is needed to develop

related equipment and a standardized process. The soybean dal product must conform to traditional dal in appearance both before and after cooking to effectively promote its use.

In addition, a study on production costs for a small soybean dal processing industry is needed. Soybean dal would have to be competitive with native dals.

A. Objectives

Objective 1:

Design and develop equipment for dehulling and splitting of whole soybeans to obtain dal (target date for completion - year 2).

Objective 2:

Establish a process for tenderizing whole and split soybeans (target date for completion - year 2).

Objective 3:

Design and develop low-cost dryer in association with wet pre-treatment processes (parboiling) (target date for completion - year 3).

Objective 4:

Establish at CIAE a village level and small industry soybean dal processing unit (target date for completion - year 5).

B. Personnel Levels (A-available, N-new)

Scientist-in-charge

(A)	Scientist S-3 Process Engineer	(50%)
(N)	Scientist S-2 Process Engineer (Pilot Plant)	(50%)
(N)	Scientist S-2 Cereal Technology/Food Science	(50%)
(N)	Scientist S-2 Food and Nutrition/Home Science	(25%)
(A)	Senior Technician T-4 Process Engineer	(40%)
(A)	Senior Technician T-4 Food Technology	(25%)
(N)	Senior Technician T-6 Home Science/Nutrition	(25%)

C. Training Programs

Training programs for the above scientists are included under Component 1.

D. Equipment

Year 1	$	Rs
Strain indicator and guage		18,000
Oscilloscope		25,000
Burr mill		5,000
Total		Rs 48,000

E. Consulting Services

University of Illinois, Urbana, Illinois. INTSOY. Dept.of Food Science. Soybean Processing Specialist: Soybean foods from whole soybeans. Year 1 - 1 month. Year 3 - 1 month.

F. Principal Reports, Reviews and Evaluations

The subproject will be reviewed and evaluated annually. Yearly subproject reports will be prepared and included in the CIAE annual report.

Component research results will be published in appropriate scientific journals.

G. End of Subproject Status

1. The availability of simple equipment to process soybean dal at the home and village level.

2. The standardization of a process and equipment for establishing a small soybean dal processing industry.

3. The establishment of improved processing methods for dehulling soybeans.

4. The development of a soybean dal similar to traditional dal in respect to appearance and cooking qualities.

5. The consumption of soybeans as a traditional food in the Indian diet.

All objectives relating to process and equipment development should be met by the end of the subproject. Additional work will be needed in the establishment of a small soybean dal processing industry. An economic feasibility study will be needed.

COMPONENT 2

DAL FROM SOYBEANS

ITEM	YEAR 1 $	YEAR 1 Rs	YEAR 2 $	YEAR 2 Rs	YEAR 3 $	YEAR 3 Rs	YEAR 4 $	YEAR 4 Rs	YEAR 5 $	YEAR 5 Rs	TOTAL $	TOTAL Rs
Training												
U.S.												
India												
Workshops and Conferences												
Consulting	15,000		15,000		15,000						45,000	
Research Equipment												
U.S.												
India		48,000										48,000
Maintenance a/		9,600		9,600		9,600		9,600		9,600		48,000
Facilities		203,026		8,740		8,740		8,740		8,740		237,986
Office Equipment and Supplies		42,860		28,570		14,286		14,286		7,142		107,144
Maintenance b/		4,286		7,142		8,572		10,000		10,714		40,714
Operational Research								128,570		64,290		192,860
Vehicles												
India												
Maintenance c/												
Staff												
Present		24,100		25,036		25,966		26,900		27,836		129,838
New		35,750		36,816		37,896		38,960		40,040		189,462
In-country travel		7,145		7,145		7,145		7,145		7,145		35,725
TOTAL	15,000	374,767	15,000	122,453	15,000	112,[illegible]05		244,201		175,507	45,000	1,029,729

a/ Includes spare parts, installations and fittings.
b/ Includes recurring expenses.
c/ Includes recurring expenses.

Component 3

The development of low-cost extrusion cooking processes and equipment for soybean flour and other soy products applicable to the small industry level.

Low-cost extrusion cooking (LEC) is a thermal process which can be used for converting coarsely ground, unhulled or dehulled soybeans into a precooked flour. Anti-nutritional factors are destroyed, protein digestibility is increased, and off-flavor development is inhibited. Low-moisture raw material is used. A high temperature develops in the extruder due to friction. The final product is precooked nonuniform grits which can be ground into a flour. The final product has a low moisture, thereby eliminating the need for drying. The precooked full-fat soy flour is of high nutritional value.

The introduction of LEC technology and equipment development in India has been limited. Knowledge of the extrusion equipment design is needed. This processing system can be used to establish a small (5 - 8 MT/per day) soybean flour processing industry.

Extensive research in soybean process development, pilot plant design, and nutritional evaluation of extruded soy products based on LEC technology has been conducted at Colorado State University, Fort Collins, Dept. of Agricultural Engineering and Dept. of Nutrition. It is proposed that training programs be established for three CIAE scientists in process development and equipment design.

A. Objectives

Objective 1:

Develop a simple low-cost cooker extruder to process soybeans into precooked full-fat flour (target date for completion - year 3).

Objective 2:

Establish processing parameters for a low-cost extrusion technology system (target date for completion - year 3).

Objective 3:

Develop product identity and nutritional standards for extruded full-fat soybean flour (target date for completion - year 4).

Objective 4:

Develop related equipment for a low-cost extrusion processing system (target date for completion - year 5).

Objective 5:

Establish at CIAE a small soybean flour processing industry (pilot plant) based on low cost extrusion technology (target date for completion - year 5)

B. Personnel Levels (A-available, N-new)

Scientist-in-charge

(A)	Scientist S-3 Process Engineer/Design Engineer	(50%)
(A)	Scientist S-1 Cereal Technology/Food Technology	(50%)
(N)	Scientist S-3 Food Technology/Food Science	(50%)
(N)	Scientist S-2 Process Engineer (Tech. Transfer)	(50%)
(N)	Scientist S-2 Process Engineer (Pilot Plant)	(50%)
(A)	Senior Technician T-4 Process Engineer	(20%)
(A)	Senior Technician T-4 Food Technology	(25%)
(N)	Senior Technician T-6 Process Engineer	(50%)

C. Training Programs

(A)	Scientist S-3 Process Engineer/ Design Engineer Year 1 3 months	Colorado State University Dept. of Agricultural Engineering Training program: low-cost extrusion cooking technology
(N)	Scientist S-2 Process Engineer (Pilot Plant) Year 2 3 months	Colorado State University Dept. of Agricultural Engineering Training program: low-cost extrusion cooking technology
(N)	Senior Technician T-6 Process Engineer Year 2 3 months	Colorado State University Dept. of Agricultural Engineering Training program: low-cost extrusion cooking technology
(N)	Scientist S-2 Process Engineer (Technology transfer) Year 3 5 months	Colorado State University Dept. of Agricultural Engineering Training program: low-cost extrusion cooking technology

D. Equipment

Year 2	$	Rs
Alpine pin mill	20,000	
Low-cost extrusion cooker and accessories	35,000	
Steam boiler with feed water softening		150,000
Lab extruder (high moisture)	20,000	
Rotary cooler		40,000
Total	$ 75,000	Rs 190,000

E. Consulting Services

Colorado State University, Fort Collins, Dept. of Agricultural Engineering. Soybean Processing Specialist. Low-cost extrusion technology. Year 2 - 1 month. Year 3 - 1 month. Year 5 - 1 month.

F. Principal Reports, Reviews and Evaluations

The subproject will be reviewed and evaluated annually. Yearly subproject reports will be prepared and included in the CIAE annual report. Overall component research results will be published in appropriate scientific journals.

G. End of Subproject Status

1. The design and development of a simple low-cost extruder cooker for processing soybeans into full-fat flour.

2. The establishment of quality standards for an extruded full-fat soybean flour.

3. The development of related equipment for a low-cost extrusion technology processing system.

A low-cost extruder for processing soybeans into full-fat soybean flour should be developed by the end of the subproject. The related equipment including a hull separator and a cooker should be developed. Quality standards for extruded full-fat soybean flour should be established. Additional work will be needed for further soybean product development and the set-up of a pilot plant facility under the operational research program. An economic feasibility study will be needed.

COMPONENT 3

LOW-COST EXTRUSION COOKING

ITEM	YEAR 1 $	YEAR 1 Rs	YEAR 2 $	YEAR 2 Rs	YEAR 3 $	YEAR 3 Rs	YEAR 4 $	YEAR 4 Rs	YEAR 5 $	YEAR 5 Rs	TOTAL $	TOTAL Rs
Training												
U.S.	15,000		25,000		25,000						65,000	
India												
Workshops and Conferences												
Consulting	15,000		15,000		15,000				15,000		60,000	
Research Equipment												
U.S.			111,375								111,375	
India				209,000								209,000
Maintenance[a]				190,300		190,300		190,300		190,300		761,200
Facilities		203,026		8,740		8,740		8,740		8,740		237,986
Office Equipment and Supplies		42,860		28,570		14,286		14,286		7,142		107,144
Maintenance[b]		4,286		7,142		8,572		10,000		10,714		40,714
Operational Research								128,570		64,290		192,860
Vehicles												
India												
Maintenance[c]												
Staff												
Present		30,300		31,457		32,615		33,770		34,932		163,074
New		49,000		50,565		52,145		53,710		55,290		260,710
In-country travel		7,145		7,145		7,145		7,145		7,145		35,725
TOTAL	30,000	336,617	151,375	532,919	40,000	313,505		446,521	15,000	378,553	236,375	2,008,413

a/ Includes spare parts, installations and fittings.
b/ Includes recurring expenses.
c/ Includes recurring expenses.

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Component 4

The development of processes and equipment for preparing low-fat soybean flour applicable to the village and small industry level.

In India, soybeans are primarily processed into oil and soybean meal, the latter being used for animal feed. Large volume solvent extraction plants (50 - 60 MT/per day) operated near capacity can efficiently process soybean into oil and high-quality flour. However, such plants involve large investments and high fixed costs.

Considerable interest has been given to using expellers (mechanical presses) to process soybeans. A study was conducted in 1974 at the Agro Processor Private Limited of Nagpur, Maharashtra, in cooperation with N.K.V.V., Jabalpur and the University of Illinois, College of Agriculture. This experimental study illustrated that the alternative small-scale soybean processing system (1MT/day) could be used to produce a low-fat soybean flour (5% oil). The heat generated during the process must be regulated to avoid excessive heating and darkening of the product. The expelling process requires that the soybean material undergo three passes, therefore, the energy requirements is greatly increased.

An acceptable study of expeller-processed low-fat soy flour was conducted in which a blend of 20% soy flour and 80% wheat flour was used to prepare chapattis. The soy-supplemented chapattis received a favorable response in 80% of the quality characteristics that were evaluated. The soy-supplemented chapattis were downgraded, however, for odor during cooking, taste and overall palatability, quality attributes which are very important in determining potential food product usage.

Further work is needed to develop an efficient method for processing soybeans into a low-fat flour. Equipment modification to an expeller system and the development of new equipment should be investigated.

Research activities at CIAE have included an investigation into the performance of a power ghani (mortar/pestle system) for extracting oil from groundnuts. The use of this traditional equipment for soybeans should be investigated. Additional research is needed to fabricate prototype equipment capable of processing soybeans into a low-fat flour at the village level. Technology transfer to a small industry unit is desirable. An investigation into new technology methods for low-capacity refining of soybean oil is needed.

A. Objectives

Objective 1:

Design and develop a manual and bullock operated oil expeller for soybean processing. (target date for completion - year 3)

Objective 2:

Establish quality and nutritional standards for low-fat soybean flour obtained from newly developed expeller equipment. (target date for completion - year 4)

Objective 3:

Design and develop a low-cost process and equipment for refining soybean oil at the village level. (target date for completion - year 5)

Objective 4:

Investigate the utilization of low-fat soy flour (expeller processed) in treaditional foods such as chapattis. (target date for completion - year 5)

Objective 5:

Establish at CIAE a village and small industry level (pilot plant) for processing soybeans into low-fat soybean flour and oil. (target date for completion - year 5)

B. Personnel Levels (A-available, N-new)

Scientist-in-charge

(A)	Scientist S-1 Process Engineer/Chemical Engineer	(50%)
(N)	Scientist S-2 Process Engineer (Tech. transfer)	(50%)
(A)	Senior Technician T-4 Biochemist	(25%)
(N)	Senior Technician T-6 Process Engineer	(25%)

C. Training Programs

All training programs for scientists under Component 1; namely, courses on soybean food uses, the chemistry of soybean protein; and the nutritional and organoleptic evaluation of soy products, would support the objectives of this component.

D. Equipment

Year 1	$	Rs
Laboratory fat-extractor		15,000
Total year 1		Rs 15,000

Year 2	$	Rs
Drum drier	5,000	
Laboratory flaking mill	2,000	
Total year 2	$ 7,000	

Year 3		
Solvent-oil extracting unit (low capacity) (50-100 kg/hr)		450,000
Total year 3		Rs 450,000

Grand Total	$ 7,000	Rs 465,000

E. Consulting Services

Soybean Processing Specialist - Oil Extraction and Refining. Year 2 - 1 month, Year 4 - 1 month.

F. Principal Reports, Reviews and Evaluations

The subprojecat will be reviewed and evaluated annually. Yearly subproject reports will be prepared and included in the CIAE annual report. Component research results will be published in appropriate scientific journals.

G. End of Subproject Status

1. The development of simple equipment for processing soybeans into oil and low-fat flour.

2. The establishment of quality and nutritional standards for low-fat soybean flour.

Additional research will be needed to develop a low-cost village process nad equipment to refine soybean oil. Studies will be needed on the utilization of low-fat soybean flour in Indian foods. More work will be needed in operational research to establish a village and small industry level unit for processing soybeans into low-fat soybean flour and oil. An economic feasibility of the process should be conducted.

COMPONENT 4

LOW-FAT SOYBEAN FLOUR

ITEM	YEAR 1 $	YEAR 1 Rs	YEAR 2 $	YEAR 2 Rs	YEAR 3 $	YEAR 3 Rs	YEAR 4 $	YEAR 4 Rs	YEAR 5 $	YEAR 5 Rs	TOTAL $	TOTAL Rs
Training												
U.S.												
India												
Workshops and Conferences												
Consulting	15,000		15,000		15,000		15,000		15,000		75,000	
Research Equipment												
U.S.			10,395								10,395	
India		15,000				540,000						555,000
Maintenance[a]		3,000		16,860		124,860		124,860		124,860		394,440
Facilities		203,026		8,740		8,740		8,740		8,740		237,986
Office Equipment and Supplies		42,860		28,570		14,286		14,286		7,142		107,144
Maintenance[b]		4,286		7,142		8,572		10,000		10,714		40,714
Operational Research								128,570		64,290		192,860
Vehicles												
India												
Maintenance[c]												
Staff												
Present		12,500		13,023		13,549		14,070		14,598		67,740
New		17,000		17,533		18,073		18,605		19,145		90,356
In-country travel		7,145		7,145		7,145		7,145		7,145		35,725
TOTAL	15,000	304,817	25,395	99,013	15,000	735,225	15,000	326,276	15,000	256,574	85,395	1,721,965

a/ Includes spare parts, installations and fittings.
b/ Includes recurring expenses.
c/ Includes recurring expenses.

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Component 5

The development of processes and equipment for soy flour supplemented baked foods applicable to the small industry level.

Extensive research has been conducted in the U.S. on the utilization of soybean flours, full-fat and low-fat, in baked foods. Investigations have included soy-flour supplemented loaf-type bread and biscuits (cookies). Soy flour substitution levels for wheat flour are 5 - 15%.

Nutritional analyses of experimental baking trials on soy-fortified breads and biscuits conducted at Kansas State University showed that the protein quality and quantity of these products are greatly improved. The utilization of soy flour in a leavened product such as bread, however, is detrimental to the volume and bread characteristics. Chemical additives of soy flour without affecting physical qualities.

Research needs to be conducted in developing a process and related equipment to produce soy-supplemented loaf-type bread and biscuits which are acceptable in India. This investigation must be conducted with an understanding of the existing methods used for bread and biscuit production. The utilization of soy flour in a familiar, acceptable finished product can increase the demand for soybean flour. Although the consumption of these baked foods is concentrated in the urban areas, soy flour supplementation can support a rural soybean flour industry.

The addition of soy flour in a bread formulation will increase water absorption and bread yield. However, detrimental factors relating to decreased volume can be minimized through a modified process for dough development and formulation.

Component research should include the development and adaptation of a dough-preparation procedure which uses low-energy dough development. A mechanical procedure would be the use of a sheeting roll (doughbrake) which develops the dough by passing it through the roller a number of times.

Research will concentrate on the use of full-fat soy flour.

A. Objectives

Objective 1:

Survey existing methods used by small industries for making popular baked goods (bread and biscuits) in India. (target date for completion - year 2)

Objective 2:

Develop processe and related equipment needed to prepare soy flour-supplemented baked goods. (target for completion - year3)

Objective 3:

Standardize a procedure for preparing soy flour-supplemented bread adaptable to the existing small baked goods industry. (target date for completion - year 4)

Objective 4:

Establish the optimum level of soy flour substitution based on product quality, acceptability, and adaptability to the present small baked goods industry. (target date for completion - year 5)

B. Personnel Levels (A-available, N-new)

Scientist-in-charge

(A) Scientist S-3 Process Engineer/Design Engineer (50%)
(N) Scientist S-2 Cereal Technology/Food Science (50%)
(N) Scientist S-2 Food and Nutrition/Home Science (25%)
(A) Senior Technician T-4 Food Technology (50%)
(N) Senior Technician T-6 Home Science/Nutrition (25%)

C. Training Programs

(N)	Scientist S-2 Cereal Technology/ Food Science Year 2 5 months	Kansas State University Dept of Grain Science and Industry Study program - experimental baking; soy-supplemented baked goods
(A)	Senior Technician T-4 Food Technology Food Science Year 3 2 months	Kansas State University, Dept of Grain Science and Industry Training program--experimental baking; soy supplemented baked goods

D. Equipment

Year 2	$	Rs
Dough mixer		30,000
Sheeting roll (2) (modern, traditional)	15,000	
Extensograph	20,000	
Dough divider		30,000
Small rotary oven		10,000
Total	$ 35,000	Rs 70,000

E. Consulting Services

Kansas State University, Manhattan. Cereal Scientist. Soy-supplemented baked goods. Year 2 - 2 months, Year 4 - 1 month.

F. Principal Reports, Reviews and Evaluations

The subproject will be reviewed and evaluated annually. Yearly subproject reports will be prepared and included in the CIAE annual report. Component research results will be published in appropriate journals.

G. End od Subproject Status

1. Information will be available on existing methods used in the small baked good (bread and biscuits) industry.

2. A process for making soy-supplemented products will be available which can adapt to the present small industry.

3. New or modified equipment will be available to aid in preparing soy flour fortified baked goods.

Additional work will be needed to establish the optimum amoung of soy flour supplementation which can be used for bread and cooked in existing small companies. Product evaluation and subsequent technology transfer (operational research) to an existing small, local bakery will require more research. The economic feasibility of the process and products (market price) is needed.

COMPONENT 5

SOYBEAN FLOUR-SUPPLEMENTED BAKED GOODS

ITEM	YEAR 1 $	YEAR 1 Rs	YEAR 2 $	YEAR 2 Rs	YEAR 3 $	YEAR 3 Rs	YEAR 4 $	YEAR 4 Rs	YEAR 5 $	YEAR 5 Rs	TOTAL $	TOTAL Rs
Training												
U.S.			25,000		10,000						35,000	
India												
Workshops and Conferences												
Consulting			15,000				15,000				30,000	
Research Equipment												
U.S.			51,975								51,975	
India				77,000								77,000
Maintenance[a]				84,700		84,700		84,700		84,700		338,800
Facilities		203,026		8,740		8,740		8,740		8,740		237,986
Office Equipment and Supplies		42,860		28,570		14,286		14,286		7,142		107,144
Maintenance[b]		4,286		7,142		8,572		10,000		10,714		40,714
Operational Research								128,570		64,290		192,860
Vehicles												
India												
Maintenance[c]												
Staff												
Present		22,000		22,835		23,665		24,500		25,335		118,335
New		23,250		23961		24,681		25,390		26,110		123,392
In-country travel		7,145		7,145		7,145		7,145		7,145		35,725
TOTAL		302,567	91,975	260,093	10,000	171,789	15,000	303,331		234,176	116,975	1,271,956

a/ Includes spare parts, installations and fittings.
b/ Includes recurring expenses.
c/ Includes recurring expenses.

Component 6

The development of processes and equipment for fermented and coagulated soy-based products applicable to the home, village and small industry level.

Paneer, a cheese product, is an important food item in an Indian vegetarian diet. Soybean cheese, also referred to as tofu, is a popular Japanese food. The traditional process uses whole soybeans but investigation can be conducted using full-fat soy flour. The processing of soybeans into tofu at the home, village and small industry level could increase soybean utilization in the form of a traditional food product.

In addition, oriental fermented soybean food products such as tempeh, miso and natto can be prepared from whole soybeans. These products have potential for utilization as part of the Indian food pattern. Similarly, these fermented foods can be prepared in the home or can be produced at the village and small industry level.

A constraint to soybean utilization is unfamiliar flavor. The fermentation process, however, develops food flavors and textures similar to that of traditional foods.

Another constraint to soybean consumption is the presence of flatulence factors (formation of gastrointestinal gas). The soaking and cooking treatment for preparing soybean and the subsequent fermentation step for making tempeh removes most of the flatus factors. Tofu and fermented soybean products have a high protein content on a solids basis. Protein digestibility and related quality is also high.

Some Indian fermented foods, namely dhokla and idli, are prepared from a batter of cereals and legumes (dal). It was reported that comparable products can be make from soybeans in place of the usual legume.

This area of soybean food products has not been widely research in India.

A. Objectives

Objective 1:

Develop a simple process and equipment for making soybean cheese (tofu). (target date for completion - year 3)

Objective 2:

Develop a simple process and equipment for making soybean fermented foods including tempeh, miso, and natto. (target date for completion - year 3)

Objective 3:

Evaluate the product quality of coagulated (cheese) and fermented soy products and establish product standards. (target date for completion - year 5)

Objective 4:

Adapt processes and equipment for fermented and coagulated soy-based foods to the village and small industry level. (target date for completion - year 5)

B. Personnel Levels (A-available, N-new)

Scientist-in-charge

(A)	Scientist S-2 Biochemistry/Microbiology	(50%)
(N)	Scientist S-3 Food Chemist/Biochemist/Cereal Technology	(50%)
(N)	Scientist S-3 Food Technology/Food Science	(50%)
(N)	Scientist S-1 Process Engineer/Food Engineer	(50%)
(A)	Senior Technician T-4 Biochemist	(50%)
(N)	Senior Technician T-4 Process Engineer	(25%)

C Training Programs

(N)	Scientist S-3 Food Technology/ Food Science Year 2 3 months	University of Illinois, Urbana Dept. of Food Science Training program--fermented and coagulated soy-based products

D. Equipment Levels

Year 1

	$	Rs
Binocular microscope	7,000	
Autoclave		10,000
Total year 1	$ 7,000	Rs 10,000

Year 2

BOD/CO_2 incubator		22,500
Freezers (2)		36,000
SS formulation tank with stirrer		35,000
Collodial mill	3,000	
Sterilizer air chamber		25,000
Two stage homogenizer	9,000	
PO pump for slurries		20,000
Total year 2	$ 12,000	Rs 138,500

Year 3

	$	Rs
Tofu processor	35,000	
Freeze drier	4,000	
Total year 3	$ 39,000	
Grand total	$ 58,000	Rs 148,500

E. Consulting Services

University of Illinois, Urbana, Dept. of Food Science. Food Scientist. Soybean and fermented foods (Dr. Wei). Year 2 (end) - 1 month. Year 3 (end) - 1 month. Year 5 - 1 month.

F. Principal Reports, Reviews and Evaluations

The subproject will be reviewed and evaluated annually. Yearly subproject reports will be prepared and included in the CIAE annual report. Component research results will be published in appropriate journals.

G. End of Subproject Status

1. The development of a simple process for making soybean cheese and several fermented soy foods.

2. The adaptation of simple processes to prepare coagulated and fermented soy foods in the home.

3. The initial set-up at CIAE of a processing unit for perparing coagulated and fermented soy foods.

Some processing equipment will be developed. Further research will be necessary for equipment development and product evaluation. The adaptation of processes and equipment to the village and small industry level will not be completed. The latter will include product standardization. An operational research program will focus on establishing a pilot plant unit at the village level. Further work will be needed in marketing and the economic feasibility of the processing technology.

COMPONENT 6

FERMENTED AND COAGULATED SOY-BASED PRODUCTS

ITEM	YEAR 1 $	YEAR 1 Rs	YEAR 2 $	YEAR 2 Rs	YEAR 3 $	YEAR 3 Rs	YEAR 4 $	YEAR 4 Rs	YEAR 5 $	YEAR 5 Rs	TOTAL $	TOTAL Rs
Training												
U.S.			15,000								15,000	
India												
Workshops and Conferences												
Consulting			15,000		15,000				15,000		45,000	
Research Equipment												
U.S.	9,450		17,820		63,180						90,450	
India		10,000		152,350								162,350
Maintenance[a]		14,600		68,830		153,070		153,070		153,070		542,640
Facilities		203,026		8,740		8,740		8,740		8,740		237,986
Office Equipment and Supplies		42,860		28,570		14,286		14,286		7,142		107,144
Maintenance[b]		4,286		7,142		8,572		10,000		10,714		40,714
Operational Research								128,570		64,290		192,860
Vehicles												
India												
Maintenance[c]												
Staff												
Present		19,500		20,190		20,880		21,570		22,265		104,405
New		43,500		45,033		46,573		48,105		49,645		232,856
In-country travel		7,145		7,145		7,145		7,145		7,145		35,725
TOTAL	9,450	344,917	47,820	338,000	78,180	259,266		351,486	15,000	323,011	150,450	1,656,680

a/ Includes spare parts, installations and fittings.
b/ Includes recurring expenses.
c/ Includes recurring expenses.

COMPONENT 7

The establishment of appropriate systems technologies for handling, storage and packaging whole soybeans and soy products.

Whole soybeans are subjected to loss of viability during storage. The mechanical injury to soybeans during harvesting, handling and threshing can accelerate rancidity development and product quality losses upon processing. Total soybean loss due to mechanical injury (cracked soybeans) is estimated at 2%. The loss of viability is estimated at 40-50%. Although total post-harvest losses for soybeans, from harvesting to marketing is estimated at 10-15%, soybean processing losses (processing-packaging-storage) is estimated at 5-8%.

Processed soy products are susceptible to spoilage and loss of nutritional value due to improper storage and poor packaging techniques.

Studies have been conducted at CIAE on improved practices for whole soybean storage at the farm level. Work has been initiated on modifying existing traditional storage structures. Continued long-term research is needed. Some research has also been initiated on the suitability of different packaging materials for rice flour and dal.

Additional research is needed to determine proper packaging materials for processed soy products. An investigation is necessary to determine the shelf life of these products. The findings can indicate the need for modifications to the processing systems, improvement in quality control procedures and the use of additives to maintain good shelf life.

A. Objectives

Objective 1:

Identify the structures suitable for whole soybean storage at the farm level. (target date for completion - year 3)

Objective 2:

Identify the proper packaging materials for processed soy products. (target date for completion - year 5)

Objective 3:

Evaluate the quality of stored soybeans. (target date for completion - year 5)

Objective 4:

Test the nutritional quality related to shelf life of store processed soy products. (target date for completion - year 5)

B. Personnel Levels (A-available, N-new)

Scientist-in-charge

(A) Scientist S-1 Process Engineer/Chemical Engineer (50%)
(N) Scientist S-1 Process Engineer/Food Engineer (50%)
(A) Senior Technician T-4 Process Engineer (20%)

C. Training Programs

(A)	Scientist S-1 Process Engineer/Chemical Engineer Year 2 5 months	Kansas State University Dept. of Grain Science and Industry Course program - storage of soybeans and soy products
(N)	Scientist S-1 Process Engineer/Food Engineer Year 3 2 months	Michigan State University School of Packaging Training program - packaging of soy products

D. Equipment

Year 1

	$	Rs
Potentiometric multipoint temerature recorder	4,500	
Storage silos/surge bins (5 each)		10,000
Total year 1	$ 4,500	Rs 10,000

Year 2

Controlled environment test chamber		180,000
General instruments controls (humidity, temperature)		50,000
Thermohygrographs (5)		30,000
Bucket elevator		15,000
Screw conveyors (2)		15,000
Total year 2		Rs 290,000
Grand total	$ 4,500	Rs 300,000

E. Consulting Services

University of Illinois, Urbana, Dept. of Agricultural Engineering. Agricultural Engineer. Soybean storage as a food grain: Year 1 - 1 month; Year 5 - 1 month.

Michigan State University. School of Packaging. Food Packaging Specialist. Year 3 - 1 month; Year 5 - 1 month.

F. Principal Reports, Reviews and Evaluations

The subproject will be reviewed and evaluated annually. Yearly subproject reports will be prepared and included in the CIAE annual report. Component research results will be published in appropriate journals.

G. End of Subproject Status

1. The development of suitable structures for on-farm soybean storage.

2. Improved handling and packaging of soybean and soy-products.

Additional research will be needed to identify proper packaging materials and storage methods for processed soy products which will enter the local market. An economic feasibility study should also be conducted.

An operational research program will be needed to focus on the testing of improved storage systems at the village level and the demonstration of suitable packaging methods for soybean foods for small industry operations.

COMPONENT 7

HANDLING, STORAGE AND PACKAGING - SOYBEANS AND SOY PRODUCTS

ITEM	YEAR 1 $	YEAR 1 Rs	YEAR 2 $	YEAR 2 Rs	YEAR 3 $	YEAR 3 Rs	YEAR 4 $	YEAR 4 Rs	YEAR 5 $	YEAR 5 Rs	TOTAL $	TOTAL Rs
Training												
U.S.			25,000		10,000						35,000	
India												
Workshops and Conferences												
Consulting	15,000				30,000				15,000		60,000	
Research Equipment												
U.S.	6,075										6,075	
India		10,000		319,000								329,000
Maintenance[a]		10,100		73,900		73,900		73,900		73,900		305,700
Facilities		203,026		8,740		8,740		8,740		8,740		237,986
Office Equipment and Supplies		42,860		28,570		14,286		14,286		7,142		107,114
Maintenance[b]		4,286		7,142		8,572		10,000		10,714		40,714
Operational Research								128,570		64,290		192,860
Vehicles												
India												
Maintenance[c]												
Staff												
Present		11,800		12,289		12,781		13,270		13,764		63,904
New		9,000		9,355		9,715		10,070		10,430		48,570
In-country travel		7,145		7,145		7,145		7,145		7,145		35,725
TOTAL	21,075	298,217	25,000	466,141	40,000	135,139		265,981	15,000	196,125	101,075	1,361,603

a/ Includes spare parts, installations and fittings.
b/ Includes recurring expenses.
c/ Includes recurring expenses.

COMPONENT 8

Supportive Training Program in Oilseed Processing and Utilization. There is dearth of trained engineers and scientists in the ara of PHT of oilseeds. Trained personnel are required for R&D efforts,m planning and execution of developmental efforts in oilseed processing and utilization. It is, therefore, necessary to have PHT engineers, scientists and technologiests trained in India and abroad for required period of time. At the same time young engineers/scientists/ technologists having aptitude/liking to work in the area of PHT of oilseeds, particularly soybeans, can be picked up for training for thier M.Tech or Ph.D or equivalent degree programs. This training program depending upon situation could be organized in India and USA. Thesis research in these programs will be taken up complimentary to applied and adoptive research components of this Indo-US collaborative program.

A. Objectives

This supportive training program is directed to strengthen applied and associated basic research program through Masters and Doctoral training and research in the area of PHT of oilseeds in general and soybeans in particular. The trained manpower will not only cater to the R&D personnel requirements but also meet the requirement of developmental programs related to oilseed processing and utilization.

Objective 1:

Short term training and study tours of selected PHT Engineers/Scientists/technologists in processing and utilization of soybeans, in India and US.

Objective 2:

To train graduates of Agricultural Engineer/PHT Sciences/Technology for Masters' and Doctoral programs with course work completed jointly in India and US, thesis work done in India and degree awarded by Indian University.

Objective 3:

To undertake basic and applied research complimentary to applied and adoptive research program in India through Masters and Doctoral thesis work with an emphasis on research related to components 1 to 6 of this Subproject.

B. Personnel Levels

In addition to existing faculty, technical and other supporting staff, the following additional staff shall be provided at GBPUAT Pantnagar for this component activity:

Post	Pay Scale	No.
Professor (Process Engg.)	1500-2500	1
Professor (Food Tech.)	1500-2500	1
Associate Professor (Process Engg.)	1200-1900	1
Associate Professor (Food Tech.)	1200-1900	1
Research Associates Process Engg./Food Tech.	1000/800 fixed	1/1
Sr. Mechanic/Sr. Lab Tech.	280-450	2
Jr. Stenographer/Stenotypist	300-500	1
Administrative Asstt.	300-500	1
Sr. Research Fellow (For 3 years each)	600 for 2 yrs. 700 in 3rd yr.	2 per year
Jr. Research Fellow (for 2 years each	400	4 per year

C. Training Programs*

(i) Short term training/Study tours of 2-3 months durations for PHT Scientists/Engineers/ Technologists: Total 15 man months. (1st year: 3 man-months; 2 year: 5 man-months; 3rd year: 5 man months; 4th year: 2 man-months).

(ii) Study tour/Course work of one trimester (3months) duration for Sr. Researfh Fellow in 2nd year: Total of 24 man months.

(2nd year: 6 man months; 3rd year: 6 man months; 4th year: 6 man months; 5th year: 6 man months)

D. Equipment

To be decided later as per the requirements of M.Tech./Ph.D research programs. However a provision of US $ 18,000 and Rs 1,34,500 has been made for this purpose.

* Nominees for training and places of training will be decided by Subproject Implementation Committee.

COMPONENT 8

SUPPORTIVE U.S. TRAINING PROGRAM IN OILSEED PROCESSING AND UTILIZATION

ITEM	YEAR 1 $	YEAR 1 Rs	YEAR 2 $	YEAR 2 Rs	YEAR 3 $	YEAR 3 Rs	YEAR 4 $	YEAR 4 Rs	YEAR 5 $	YEAR 5 Rs	TOTAL $	TOTAL Rs
Training												
U.S.	15,000		37,000		37,000		12,000		12,000		123,000	
India												
Workshops and Conferences												
Consulting												
Research Equipment												
U.S.	6,000		6,000		6,000						18,000	
India		45,000		45,000		44,500						134,500
Maintenance a/		18,000		36,000		52,000		52,000		52,000		210,000
Facilities												
Office Equipment and Supplies												
Maintenance b/												
Operational Research												
Vehicles												
India												
Maintenance c/												
Staff												
Present												
New		103,200		192,100		240,000		244,400		248,800		1,028,500
In-country travel		3,000		6,000		8,000		8,000		8,000		33,000
TOTAL	21,000	169,200	43,000	279,100	43,000	344,500	12,000	304,400	12,000	308,800	141,000	1,406,000

a/ Includes spare parts, installations and fittings.
b/ Includes recurring expenses.
c/ Includes recurring expenses.

COMMON TO ALL COMPONENTS

Personnel Levels

(N) Project Director - Scientist S-4 Process Engineer
(A) Scientist S-3 Food Engineer/Production Engineer
(N) Scientist S-2 Ind. Management/Systems Economics
(N) Senior Technician T-6 Economics
(N) Senior Technician T-6 Statistics

Training Programs

It is proposed that training programs abroad be established for Indian professionals at the post-graduate level. In addition, training programs for two senior technicians are proposed. Specific short courses and study tours will focus on laboratories, universities, institutions, processing plants and equipment manufacturers involved in soybean processing and utilization technologies. A systematic professional interchange can be established among senior Indian and foreign scientists related to new research developments in soybean processing and utilization. Accordingly, scientists at the CIAE will participate in training programs abroad of a short duration (one-five months) for a total of 58 months.

Program	
(N) Project Director Scientist S-4 Process Engineer Year 1 2 months	Study tour (USA) - (Orient) Soybean equipment manufacturers, soybean processing industries, soybean processing and utilization research institutes
(A) Scientist S-3 Food Engineer/ Production Engineer Year 1 2 months	Study tour (USA) - (Orient) Soybean equipment manufacturers, soybean processing industries, soybean processing and utilization research institutes
(N) Scientist Ind. Management/ Systems Economics Year 3 5 months	Food marketing, study program

Observation Tours

Scientists

D.G., ICAR/Secretary - Dept. of Agricultural Research and Education

100% 1547

Year 1 - 1 month

Deputy D.G. (Soils, Agronomy and Engineering), ICAR
Year 1 - 1 month

Asst. D.G. (Agricultural Engineering), ICAR
Year 2 - 2 months

Program

Assessment and evaluation of training programs. Visits to soybean research institutes and universities; soybean equipment manufacturers and soybean processing industries.

Conferences and Workshops Organization

National (5) - 1 each year
International (1) - year 4
Participants in International W/S abroad (4) - 8 weeks (2 weeks each) - year 2, 3, 4, 5

Equipment

Library supplies:

	$	Rs
Audiovisual aids (camera, slide projector, film projector)		45,000
Microfilm reader	2,000	
Microfilms	8,000	
Film on soybean processing	200	
Photocopier		200,000
Scientific journals, books	11,250	
Subscriptions	2,500	
Total	$ 23,950	Rs 245,000

Vehicles

Jeep	80,000
Trailer	10,000
Mobile Product Evaluation Lab a/	100,000
Automobile	75,000
Total	Rs 265,000

a/ Vehicle which will transport simple processing equipment, materials, supplies and products to interact with potential users.

Consulting Services

The subproject includes short-term visits of U.S. professional personnel to India. The U.S. personnel will be drawn from top level specialists in fields related to specific research areas. This technical expertise would strengthen project research activities and objectives. The duration of the visit of each consultant is one month with a total provision of 27 man-months.

Food Marketing Specialist
Year 4 - 1 month
Year 5 - 1 month (all components)

Subproject Evaluation

Two subproject evaluations will be conducted during the five-year subproject period. Two consultants (3 weeks each) will participate on the evaluations to be conducted at the beginning of year 3 and during year 5.

100% 1547

POST HARVEST TECHNOLOGY SCHEME CENTRES

1. Central Institute of Agricultural Engineering (ICAR)
(Coordinating Centre)
Guru Tegh Bahadur Complex
T T Nagar, Bhopal-462 003
INDIA

2. Punjabrao Krishi Vidyapeeth
(College of Agricultural Engineering)
Akola-444 001, Maharashtra
INDIA

3. Tamil Nadu Agricultural University
(College of Agricultural Engineering)
Coimbatore-641 003, Tamil Nadu
INDIA

4. Central Rice Research Institute
Cuttack-753 006, Orissa
INDIA

5. Jawaharlal Nehru Krishi Vishwa Vidyalaya
(College of Agricultural Engineering)
Jabalpur-482 004, M.P.
INDIA

6. Indian INstitute of Technology
(Post Harvest Technology Centre)
Kharagpur-721 302, West Bengal
INDIA

7. Punjab Agricultural University
College of Agricultural Engineering)
Ludhiana-141 004, Punjab
INDIA

8. Govind Ballabh Pant University of Agriculture and Technology
Department of Agricultural Engineering)
Pantnagar-263 145, Uttar Pradesh
INDIA

9. University of Agricultural Sciences
Main Research Station, Hebbal
Bangalore-560 024, Karnataka
INDIA

10. University of Udaipur
(College of Technology and Agricultural Engineering
Udaipur-313 001, Rafasthan
INDIA

11. Central Plantation Crops Research Institute
Kasaragod-670 124, Kerala
INDIA

12. Gujarat Agricultural University
(College of Agricultural Engineering)
Junagadh-362 001, Gujarat
INDIA

13. Central Tuber Crops Research Institute
Sreekariyam Post, Trivandrum-695 006
Kerala
INDIA

14. Central Arid Zone Research Institute
Jodhpur, Rajasthan
INDIA

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Annual Reviews

Project review will be conducted annually during the life of the project. The first review should take place one year after the initiation of the project. Specific areas of concentration are as follows:

1. Completion of building and laboratory facilities
2. Equipment procurement and installation
3. Personnel recruitment
4. Effectiveness of training programs
5. Collaborating bodies
6. Consulting services - requirements
7. Time schedule for programmed research activities

End of Project Status

1. Use of soybeans in the regular diet of small farmers in the rural area.

2. Consumption of soybeans by the rural as well as urban population.

3. Establishment of small soybean processing industries to serve both the rural and urban area.

4. Improved storage of soybeans at the farm level.

5. Establishment of quality standards for soybean food products.

TOTAL SUBPROJECT BUDGET SUMMARY

ITEM	Year 1 $	Year 1 Rs	Year 2 $	Year 2 Rs	Year 3 $	Year 3 Rs	Year 4 $	Year 4 Rs	Year 5 $	Year 5 Rs	Total $	Total Rs
Training												
U.S.	90,000		182,000		107,000		22,000		12,000		413 000	
India												
Workshops and Conferences		27,000	3,425	27,000	3,425	27,000	3,425	117,000	3,425	27,000	13,700	225 000
Consulting	60,000		90,000		105,000		45,000		75,000		375,000	
Research Equipment												
U.S.	192,907		262,905		88,620						544,432	
India		633,500		2,190,550		686,500						3,510,550
Maintenance a/		384,910		1,174,560		1,429,120		1,429,120		1,429 120		5 846,830
Facilities		1,421,180		61,180		61,180		61,180		61,180		1,665,900
Offi Equipment an Supplies		300,000		200,000		100,000		100 000		50,000		750 000
Maintenance b/		30,000		50,000		60,000		70,000		75,000		285,000
Operational Research								900,000		450,000		1,350,000
Vehicles												
India		265,000										265 000
Maintenance c/		53,000		53,000		53,000		53,000		53,000		265,000
Staff												
Present		96,500		200,140		207,280		214,420		221,590		939 930
New		377,200		764,400		836,700		865,500		894,200		3,737,900
In-country travel		53,000		56,000		58,000		58,000		58,000		283 000
TOTAL	342,907	3,641,290	530,330	4,776,830	304,045	3,513,780	70,425	3,868,120	98,425	3,319,090	1,346,1[illegible]	19,124,110

a/ Includes spare parts, installations and fittings.
b/ Includes recurring expenses.
c/ Includes recurring expenses.

Total subproject cost ($ + Rs) = U.S. $3,359,196

COMMON TO ALL COMPONENTS

ITEM	YEAR 1 $	YEAR 1 Rs	YEAR 2 $	YEAR 2 Rs	YEAR 3 $	YEAR 3 Rs	YEAR 4 $	YEAR 4 Rs	YEAR 5 $	YEAR 5 Rs	TOTAL $	TOTAL Rs
Training												
U.S.	70,000		50,000		75,000		50,000		50,000		295,000	
India												
Workshops and Conferences		27,000	3,425	27,000	3,425	27,000	3,425	117,000	3,425	27,000	13,700	225,000
Consulting							15,000		15,000		30,000	
Research Equipment												
U.S.	32,332										32,332	
India		245,000										245,000
Maintenance[a]		92,110		92,110		92,110		92,110		92,110		460,550
Facilities												
Office Equipment and Supplies												
Maintenance[b]												
Operational Research												
Vehicles												
India		265,000										265,000
Maintenance[c]		53,000		53,000		53,000		53,000		53,000		265,000
Staff												
Present		30,000		31,000		32,000		33,000		34,000		160,000
New		334,000		351,330		368,690		386,020		403,380		1,843,420
In-country travel												
TOTAL	102,332	1,046,110	53,425	554,440	[illegible],425	572,800	68,425	681,130	68,425	609,490	371,032	3,463,970

a/ Includes spare parts, installations and fittings.
b/ Includes recurring expenses.
c/ Includes recurring expenses.

APPENDICES

Appendix A

MAJOR SOYBEAN PRODUCTION AREA

THE CENTRAL INSTITUTE OF AGRICULTURAL ENGINEERING (CIAE)

Bhopal (M.P.)

The CIAE, established in February 1976, is located at Nabi Bagh, 5km. from Bhopal, the capital of Madhya Pradesh. The Institute is situated on a 65 hectare farm, 12 hectares of which are used for buildings and campus facilities.

This Institute implements the research objectives of the Indian Council of Agricultural Research, which is the coordinating body for its agricultural research programs. The CIAE is one of thirty-nine (39) institutes of the Indian Council of Agricultural Research.

The overall objectives of the Institute are concentrated in the development and adaption of applied research in the areas of post-harvest technology, farm equipment, and energy resources. These research areas are applicable to food, fiber, fuel crops, and their waste and by-products utilization. In addition, the Institute promotes the manufacture of processing plants and the utilization of improved technologies through specific training programs. Research and development programs are intended to cover all aspects of agricultural engineering to benefit small farmers, primary processors, small scale agro-industries, and rural processing units. The Institute promotes the adaptation of new technologies to product value added goods which have a direct effect on minimizing post-harvest losses. In addition, the transfer of proven technologies to farmers and their families, village artisans, and extension workers is undertaken at two centers - Farm Science Center and Trainers Training Center.

Relative to the proposed research subproject, the CIAE seeks a strong research program in soybean processing and utilization for developing processes and processing equipment to promote the use of soybeans in the Indian diet. Additional project interest relate to the development of village-level processing industries. The CIAE is also one of fourteen (14) institutes participating in the All-India Coordinated Post Harvest Technology Scheme, a program which would enhance the research design and objectives of the soybean subproject. Soybean processing and utilization research, therefore, could be established as the framework for an "All-India Coordinated Soybean Processing and Utilization Scheme."

An active research program in both national and international collaboration exists at CIAE. Various projects on engineering problems exist with other sister ICAR Institutes. Specific collaborative projects at the international level include: CIAE/National Institute of Agricultural Engineering - research on natural resources; India/United Kingdom; ICAR/International Rice Research Institute - small farm machinery; India/Philippines, which is AID financed; CIAE/Regional Network for Agricultural Machinery; India/Southeast-East Asia (8 countries).

The Institute has three main divisions; namely, Crop Production Engineering (CPE), Post Harvest Engineering (PHE) and Electro Mechanical Engineering (EME). In addition to the Post Harvest Technology Scheme, the Institute has a Farm Implements and Machinery Scheme. Professional staff includes the Director, 10 scientists S-3, 15 scientists S-2, 18 scientists S-1, 2 senior technicians T-6, 1 senior technician T-5, and 17 senior technicians T-4.

The CIAE Library contains over 2,800 books and 110 journals which come under the classifications of Agriculture, Agricultural Engineering, Agricultural Processing, Food and Nutrition, Food Chemistry, Chemical Engineering and Farm Structures.

The staffing pattern at CIAE is as follows:

CROP PRODUCTION ENGINEERING DIVISION

Sl No.	Post	Pay scale Rs/mo	Number of Posts Approved	Filled	Open
1.	Scientist S-3 - Tillage Technology - Sowing & Fertilizer Application Equipment - Agronomics & Field Plot Machinery	1500-2000	3	3	-
2.	Scientist S-2 - Plant Protection Equipment - Harvesting & Threshing Equipment - Sowing & Fertilizer Application Equipment	1100-1600	3	2	1
3.	Scientist S-1 - Land Development - Tillage Technology - Plant Protection Equipment - Soil & Water Management - Harvesting & Threching Equipment - Testing of Farm Machinery - Farm Machinery Management	700-1300	7	6	1
4.	Farm Superintendent T-5 - Agronomy	650-1200	1	1	-
5.	Senior Technician T-4 - Farm Equipment - Workshop Technology - Draughtsman	550-900	3	2	1
	Total		17	14	3

ELECTRO MECHANICAL ENGINEERING DIVISION

Sl No.	Post	Pay scale Rs/mo	Number of Posts Approved	Filled	Open
1.	Scientist S-3 - Instrumentation - Unconventional Sources of Energy - Photosynthetic Fuels for Energy	1500-2000	3	2	1
2.	Scientist S-2 - Workshop Technology - Solar Energy - Farm Power	1100-1600	3	3	
3.	Scientist S-1 - Wind Energy - Agricultural Waste Recycling for Energy - Rural Electrification - Photosynthetic Fuels - Farm Power - Biogas Energy - Animal Energy Sources	700-1300	7	4	3
4.	Senior Technician T-4 - Instrumentation - Prototype Production - Agro Industries	500-900	3	3	
	Total		16	12	4

POST HARVEST ENGINEERING DIVISION

Sl No.	Post.	Pay scale Rs/mo	Number of Posts Approved	Filled	Open
1.	Scientist - Agricultural Processing - Food Engineering/ Production Engineering - Process Engineering/ Design Engineering	1500-2000	3	2	1
2.	Scientist S-2 (AS&PE) - Crop Processing - Storage Technology - Drying Technology	1100-1600	3	2	1
3.	Scientist S-1 (AS&PE) - Engineering Properties of Biomaterials - Cereals Processing/Food Technology - Oilseeds Processing - Drying Technology - Farm Structures - Agricultural Wastes & By-Products Utilization - Testing of Prototypes & Pilot Plants - Materials Handling & Packaging (Process Engineering/Chemical Engineering) Technology	700-1300	8	7	1
4.	Senior Technician T-4 - Civil Engineering - Process Engineer - Drying Technology	550-900	3	1	2
	Total		17	12	5

POST HARVEST TECHNOLOGY SCHEME

Sl No.	Post	Pay scale Rs/mo	Number of Posts Approved	Filled	Open
1.	Scientist S-3 - Co-ordination - Research & Development of Post Harvest Equipment (Process Engineer)	1500-2000	2	1	1
2.	Scientist S-2 - Biochemistry/Microbiology - Entomology	1100-1600	2	2	-
3.	Scientist S-1 - Agricultural Structures & Process Engineering	700-1300	1	-	1
4.	Senior Technician T-4 - Agricultural Processing - Biochemistry - Food Technology - Mechanical Engineering - Testing of Post Harvest Equipment - Farm Structures	550-900	6	4	2
	Total		11	7	4

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FARM IMPLEMENTS & MACHINERY SCHEME

Sl No.	Post	Pay scale Rs/mo	Number of Posts Approved	Filled	Open
1.	Scientist S-3 - Co-ordination - Farm Machinery - Prototype Production	1500-2000	3	2	1
2.	Scientist S-2 - Farm Machinery	1000-1600	1	1	-
3.	Scientist S-1 - Farm Power - Farm Machinery - Testing of Agricultural Machinery	700-1300	3	1	2
4.	Senior Draughtsman T-4 - Mechanical	550-900	2	2	-
5.	Mechanical Engineer T-6	700-1300	1	-	1
6.	Foreman T-4	550-900	1	-	1
	Total		11	6	5

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KRISHI VIHYAN KENDRA (Farm Science Centre)

Sl No.	Post	Pay scale Rs/mo	Number of Posts Approved	Filled	Open
1.	Scientist S-2	1100-1600	1	1	-
2.	Training Associate T-6 - Agronomy - Farm Machinery - Animal Husbandry - Home Science - Soil & Water Conservation and Management	700-1300	5	2	3
3.	Training Assistant T-4 - Audio Visual Aids - Home Science - Animal Husbandry - Mechanical Engineering - Horticulture	550-900	5	4	1
	Total		11	7	4

TRAINERS TRAINING INSTITUTE

Sl No.	Post	Pay scale Rs/mo	Number of Posts Approved	Filled	Open
1.	Scientist S-3	1500-2000	1	-	1
2.	Scientist S-2	1100-1600	4	4	-
3.	Senior Technician T-4	550-900	1	1	-
	Total		6	5	1

SCIENTIFIC, TECHNICAL AND ADMINISTRATIVE STAFF AT CIAE (March, 1982)

Designation	Number of sanctioned posts	Number of filled posts
Scientific		
1. Director	1	1
2. Scientists Grade S-3	15	10
3. Scientists Grade S-2	17	15
4. Scientisys Grade S-1	26	18
Total	59	44
Techrical		
1. Technician Grade T-6	6	2
2. Technician Grade T-5	1	1
3. Technician Grade T-4	23	17
4. Technician Grade T-11-3	28	4
5. Technician Grade T-1	98	56
Total	156	80
Administrative		
1. Senior Administrative Officer	1	1
2. Accounts Officer	1	1
3. Assistant Administrative Officer	1	1
4. Senior Stenographer	1	1
5. Superintendent (Admin)	1	-
6. Stenographer	5	4
7. Assistant	2	1
8. Junior Stenographer	3	2
9. Superintendent (Audit & Accounts)	1	1
10. Senior Clerk	15	12
11. Junior Clerk	14	14
Total	45	38

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PERSONNEL LEVELS - RESEARCH AND DEVELOPMENT STAFF

Available*

Scientists

			Pay Scale
1.	Scientist S-3	Process Engineer	(1500-2000)
2.	Scientist S-3	Process Engineer/Design Engineer	(1500-2000)
3.	Scientist S-3	Food Engineer/Production Engineer	(1500-2000)
4.	Scientist S-2	Biochemist/Microbiology	(1100-1600)
5.	Scientist S-1	Process Engineer/Chemical Engineer	(700-1300)
6.	Scientist S-1	Cereal Technology/Food Technology	(700-1300)

Technicians

1.	Senior Tech. T-4	Process Engineer	(550-900)
2.	Senior Tech. T-4	Biochemist	(550-900)
3.	Senior Tech. T-4	Food Technology	(550-900)

New

Scientists

1.	Project Director Scientist S-4	Process Engineer	(1800-2250)
2.	Scientist S-3	Food Chemist/Biochemist/Cereal Technology	(1500-2000)
3.	Scientist S-3	Food Technology/Food Science	(1500-2000)
4.	Scientist S-2	Ind. Management/Systems Economics	(1100-1600)
5.	Scientist S-2	Process Engineer (Pilot Plant)	(1100-1600)
6.	Scientist S-2	Cereal Technology/Food Science	(1100-1600)
7.	Scientist S-2	Food and Nutrition/Home Science	(1100-1600)
8.	Scientist S-2	Process Engineer (Tech. Transfer)	(1100-1600)
9.	Scientist S-1	Process Engineer/Food Engineer	(700-1300)

Technicians

1.	Senior Tech. T-6	Economics	(700-1300)
2.	Senior Tech. T-6	Home Science/Nutrition	(700-1300)
3.	Senior Tech. T-6	Process Engineer	(700-1300)
4.	Senior Tech. T-6	Statistics	(700-1300)

*Available - Scientist pooled from existing divisions; replacements provided in respect to divisions

Supporting Staff

			Pay Scale
1.	Foreman/Sr. Lab Tech. T-4	2	(550-900)
2.	Senior Draftsman	1	(550-900)
3.	Boiler Operator, T-11-3	1	(425-700)
4.	Senior Craftsmen	2	(330-560)
5.	Craftsmen	3	(260-430)
6.	Laboratory Attendents	3	(260-430)
7.	Drivers	2	(260-430)
8.	Stenographer	1	(425-700)
9.	Senior Clerk/Accts. Clerk	2	(330-560)
10.	Junior Clerks	2	(260-400)
11.	Typists	2	(260-400)
12.	Pilot Plant Attendents	3	(196-232)
13.	Messengers	2	(196-232)
14.	Supporting Staff Grade 1	1	(196-232)
15.	Watchmen	2	(196-232)

PERSONNEL LEVELS - RESEARCH AND DEVELOPMENT STAFF (MAN YEARS)

Appendix D

Available

			Components							
Scientists			All	1	2	3	4	5	6	7
1.	Scientist S-3	Process Engineer		0.50	0.50					
2.	Scientist S-3	Process Engineer/Design Engineer				0.50		0.50		
3.	Scientist S-3	Food Engineer/Production Engineer	1.00							
4.	Scientist S-2	Biochemist/Microbiology		0.50					0.50	
5.	Scientist S-1	Process Engineer/Chemical Engineer					0.50			0.50
6.	Scientist S-1	Cereal Technology/Food Technology		0.50		0.50				
Technicians										
1.	Senior Tech. T-4	Process Engineer		0.20	0.40	0.20				0.20
2.	Senior Tech. T-4	Biochemist		0.25			0.25		0.50	
3.	Senior Tech. T-4	Food Technology			0.25	0.25		0.50		
	TOTAL		1.00	1.95	1.15	1.45	0.75	1.00	1.00	0.70

New

			Components							
Scientists			All	1	2	3	4	5	6	7
1.	Project Director Scientist S-4	Process Engineer	1.00							
2.	Scientist S-3	Food Chemist/Biochemist/Cereal Tech.		0.50					0.50	
3.	Scientist S-3	Food Technology/Food Science				0.50			0.50	
4.	Scientist S-2	Ind. Management/Systems Economics	1.00							
5.	Scientist S-2	Process Engineer (Pilot Plant)			0.50	0.50				
6.	Scientist S-2	Cereal Technology/Food Science			0.50			0.50		
7.	Scientist S-2	Food and Nutrition/Home Science		0.50	0.25			0.25		
8.	Scientist S-2	Process Engineer (Tech. Transfer)				0.50	0.50			
9.	Scientist S-1	Process Engineer/Food Engineer							0.50	0.50
Technicians										
1.	Senior Tech. T-6	Economics	1.00							
2.	Senior Tech. T-6	Home Science/Nutrition		0.50	0.25			0.25		
3.	Senior Tech. T-6	Process Engineer				0.50	0.25		0.25	
4.	Senior Tech. T-6	Statistics	1.00							
	TOTAL		4.00	1.50	1.50	2.00	0.75	1.00	1.75	0.50
	GRAND TOTAL (22.00)		5.00	3.45	2.65	3.45	1.50	2.00	2.75	1.20

TRAINING PROGRAM

(YEAR 1)

SCIENTIST	PROGRAM	COMPONENT	MONTHS
(N) Project Director Scientist S-4 Prod. Engineer	Study Tour (USA) - (Orient) Soybean equipment manufacturers, soybean processing industries, soybean processing and utilization research institutes	All	2
(A) Scientist S-3 Food Engineer/ Prod. Engineer	Study Tour (USA) - (Orient) Soybean equipment manufacturers, soybean processing industries, soybean processing and utilization research institutes	All	2
(A) Scientist S-2 Biochemist/ Microbiology	University of Minnesota Dept. of Biochemstry and Dept. of Food Science Science Program - Soybean Protein	1	5
(A) Scientist S-3 Process Engineer	University of Illinois Dept. of Food Science Soybean food uses, short Course	1	3
(A) Scientist S-3 Process Engineer/ Design Engineer	Colorado State University Training Program Low-cost extrusion cooking technology	3	3

A - Available (4) 5 Scientists
N - New (1) 15 Months

TRAINING PROGRAM

(YEAR 2)

SCIENTIST	PROGRAM	COMPONENT	MONTHS
(N) Scientist S-2 Food & Nutrition Home Science	University of Illinois Dept. of Food Science, Dept. of Foods and Nutrition: Course Program - Organoleptic Evaluation of soy products	1	5
(N) Scientist S-3 Food Chemist/ Biochemist Technology	USDA Laboratory, Peoria, Illinois Research Program - Soybean processing Nutritional evaluation of soybean products	1	3
(A) Scientist S-1 Cereal Technology/ Food Technology	University of Illinois Dept. of Food Science Soybean food uses, short courses	1	3
(N) Scientist S-2 Process Eng. (Pilot Plant)	Colorado State University Training Program: Low-cost extrusion cooking technology	3	3
(N) Senior Tech T-6 Process Eng.	Colorado State University Training Program: Low-cost extrusion cooking technology	3	2
(N) Scientist S-2 Cereal Technology	Kansas State University, Dept. of Grain Science and Industry Study Program: Experimental baking; soy-supplemented baked goods	5	5
(N) Scientist S-3 Food Technology/ Food Science	University of Illinois, Dept. of Food Science - Training program: Fermented and coagulated soy-based products	6	3
(A) Scientist S-1 Process Engineer Chemical Engineer	University of Illinois, Dept. of Agricultural Engineering - Course Program: Storage of soybeans and soy products	7	5

A - Available (2)
N - New (6)

7 Scientists
1 Technician

29 Months

TRAINING PROGRAM

(YEAR 3)

SCIENTIST	PROGRAM	COMPONENT	MONTHS
(N) Scientist S-2 Ind. Management/ Systems Economics	Food Marketing Study Program	All	5
(N) Scientist S-2 Process Engineer (Tech. Transfer)	Colorado State University Training Program: Low-cost extrusion cooking technology	3	5
(A) Senior Tech. T-4 Food Technology	Kansas State University Dept. of Grain Science Industry Trainin Program: Experimental baking; soy-supplemented baked goods	5	2
(N) Scientist S-1 Process Engineer/ Food Engineer	Michigan State University Training Program: Packaging of soy products	7	2

A - Available (1) 3 Scientists 14 Months
N - New (3) 1 Technician

OVERALL TOTALS:

A - Available (7) 15 Scientists 58 Months
N - New (10) 2 Technicians

Equipment Needed	Year 1	Year 2	Year 3
Component 1	Top-pan electronic balance Heavy duty hot air oven Auto fat analyser Auto protein analyser Refrigerators Lab. cracking mill Hammer mill Dehuller Hand grinder Lab sifter Instron Vacuum oven Potentiometric titration apparatus Voltage stablizers Cleaner/separators Graders Triple beam balances Muffle furnace Lab centrifuge (refrigerated) Bomb calorimeter Steam jacketed kettle	Lab. pin mill Alpine sieve analyser Perforated disc mill PC pump with variable speed Rotary vacuum pump Workshop tools & equipment Animal house facility Supplies (prototype equip) Volmeters Wattmeters Rotometers Potentiometers Stroboscope Transformers Electrical motors/engines Electrical motors/starters Chlorination plant Water softening plant Portable platform scale Timers Air compressor Gas liquid chromatographer Atomic absorption spectrophotometer Air conditioners	Packager Heat sealing machine Variable speed motors Stainless steel packaging table Package belt conveyors
Component 2	Strain indicator & gauge Oscilloscope Burr mill		
Component 3		Alpine pin mill Low-cost extrusion cooker & acces.	

Equipment Needed	Year 1	Year 2	Year 3
Component 3 (contd.)		Steam boiler & feed water softening Lab extruder (high moisture) Rotary cooler	
Component 4	Lab-fat extractor	Drum drier Flaking mill (lab)	Laboratory-size solvent extracting unit
Component 5		Dough mixer Sheeting roll Extensograph Dough divider Small rotary oven	
Component 6	Binocular microscope Autoclave	PO pump for slurries BOD/CO_2 incubator Freezers SS Formulation tank with stirrer Collodial mill Sterilizer air chamber Two stage homogenizer	Tofu processor Freeze drier
Component 7	Potentiometric multipt. temperature recorder Storage silos/surge bins	Control environment test chamber General instrument controls (humidity, temp.) Thermohygrographs Bucket elevator Screw conveyors	

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Equipment Needed	Year 1	Year 2	Year 3
Library Supplies	Audiovisual aids (camera, slide projector, film projector) Microfilm reader Microfilms Film on soybean processing Photo copier Scientific journals & books subscription		

Appendix G

CONSULTING SERVICES

Components	Year 1 Technical Area	Month	Year 2 Technical Area	Month	Year 3 Technical Area	Month	Year 4 Technical Area	Month	Year 5 Technical Area	Month
All							Food Marketing	1	Food Marketing	1
1, 3, 4	Soybean flours, food products & their nutritional eval. Northern Reg. Lab., Peoria, Ill.	1			Soybean flours, food products & their nutritional eval. Northern Reg. Lab., Peoria, Ill.	1				
1, 3, 4			Soybean flours and food products Dept. of Food Sci., Univ. of Illinois	1					Soybean flours and food products; Dept. of Food Sci., Univ. of Illinois	1
1, 2, 3, 4	Kansas State Univ. Dept. of Grain Sci. and Industry Milling Technologist	1			Kansas State Univ. Dept. of Grain Sci. and Industry Milling Technologist	1				
1, 2, 3, 4	Soybean foods from whole soybeans; Univ. of Illinois, Dept. of Food Science	1			Soybean foods from whole soybeans; Univ. of Illinois, Dept. of Food Science	1				
3			Low-cost extrusion technology: Colorado State University	1	Low-cost extrusion technology: Colorado State University	1			Low-cost extrusion technology. Colorado State University	1

Components	Year 1 Technical Area	Month	Year 2 Technical Area	Month	Year 3 Technical Area	Month	Year 4 Technical Area	Month	Year 5 Technical	Month
4			Oil Extrusion and Refining	1			Oil extrusion and Refining	1		
5			Soy Supplemented baked goods, Kansas State University	1			Soy supplemented baked goods, Kansas State University	1		
6			Soybean curd and fermented foods Univ. of Illinois Dr. Wei	1	Soybean curd and fermented foods Univ. of Illinois Dr. Wei	1			Soybean curd and fermented foods Univ. of Illinois Dr. Wei	1
7	Soybean storage as a food grain Univ. of Illinois Dept. of Ag. Eng.	1			Soybean storage as a food grain Univ. of Illinois Dept. of Ag. Eng.	1				
7					Food Packaging Michigan State U.	1			Food Packaging Michigan State U.	1
All					Two consultants Project evaluation (3 weeks each)				Two consultants Project. Evaluation (3 weeks each)	

Totals: 28 visits
27 months

Appendix H

Building:

Office Space	No. of positions	Space Requirement (floor area m^2)	Total space floor area m^2
Project Director	1	20	20
Scientist S-3	5	15	75
Scientist S-2	6	15	90
Scientist S-1 & T-6	7	10	70
Technicians T-4	3	10	30
Sub-total	21		205
Administrative office			65
Committee Rooms 2			50
Seminar Room 1			50
Total			450

Cost of construction for office space @ Rs 1,500 pre sq. m. Rs 6,66,000

Space for laboraory & other facilities:

Laboratory space]
Workshop]
Pilot plant] Total requirement 1000 m^2
Boiler Room]

Cost of construction of space for laboratoriesd and other facilities @ Rs 1000 per sq. m. Rs 10,00,000

Total cost of construction Rs 6,66,000 + Rs 10,00,000
= Rs 16,66,000

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