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DEVELOPMENT OF IMPROVED VARIETIES OF SOYBEANS

Annual Report on
Contract AID/CM/ta-C-73-19
April 1, 1974 to March 31, 1975

Submitted to
The U.S. Agency for International Development
Department of State
Washington, D.C.

by
The University of Illinois at Urbana-Champaign
College of Agriculture
International Soybean Program INTSOY

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REPORT SUMMARY

A. Statistical Summary

1. Project Title and Contract Number: Development of Improved Varieties of Soybeans - AID/CM/ta-C-73-19.
2. Principal Investigator, Contractor, and mailing address: William N. Thompson, Director, International Soybean Program INTSOY, College of Agriculture, University of Illinois at Urbana-Champaign, 113 Mumford Hall, Urbana, Illinois 61801.
3. Contract Period: April 1, 1973-March 31, 1976.
4. Period Covered by Report: April 1, 1974-March 31, 1975.
5. Total AID funding of contract to date: $549,995.
6. Total expenditures and obligations through previous contract year: $176,390.
7. Total expenditures and obligations for current year: $281,355.
8. Estimated expenditures for next contract year: $522,860.

B. Narrative Summary of Accomplishments

Data from the 1973-1974 trials were gathered, analyzed and prepared for dissemination. The results confirm that soybeans can be produced in most tropical and subtropical areas; however, continuing research is needed to identify yield variability from year to year, to determine the problems and hazards under the conditions of the small farmer, and to develop improved varieties adapted to his special needs under widely differing tropical and subtropical conditions. New varieties were obtained for further evaluation in Puerto Rico. The network of countries cooperating in the second year of standard varietal experiments increased from 33 to 60 and the number of experiments jumped from 90 to 136.

Soybean entomology work in pest management was strengthened through staff addition and close cooperation with staff in plant pathology. Cooperative work in Puerto Rico has begun and attention is being given to adapting the Illinois Pest Management Guidelines for use in the tropics and subtropics. Entomological research was supported by the International Reference Collection of Soybean Arthropods and the Soybean Insect Research and Information System. Through these reference systems, researchers are better able to predict what insect species and related problems can be expected where soybeans are introduced.

Additional experiments were conducted by the food science staff on tenderizing agents in the cooking process. Protein efficiency ratios were determined on a number of prototype foods made wholly or partly from field varieties of soybeans. Initial studies were made on development of concepts and equipment for village level simple processing of soybean based foods. Additional work was done on effects of corn milling techniques on drum-dried corn-soybean weaning foods.

Soybean pathology research was integrated into the research contract. The focus is on identifying soybean diseases in the tropics and subtropics, generating basic information about soybean pathogens that can be used to predict their spread and importance, devising methods to control or reduce the impact of diseases, and assisting in breeding tropically adapted soybean cultivars with resistance to important pathogens.

A "Conference on Soybean Production,Protection,and Utilization" for scientists of Africa, the Middle East and South Asia was held in Addis Ababa, Ethiopia in October 1974. Plans were made for a third conference for researchers from Asia and Oceania to be held in early 1976. These conferences,in addition to site visits and publications, facilitate utilization of research results.

Regular publication of the INTSOY Newsletter was initiated. The letter is distributed every three months, August, November, February and May. Comments from persons receiving the Newsletter indicate the major purposes of providing linkages to research in the tropics and subtropics and facilitating development of an international network of researchers are being met.

ANNUAL RESEARCH REPORT

A. General Background

Soybeans are receiving increasing attention as a food crop. The soybean has important advantages among alternative cropping choices. It produces the highest yield of protein per unit of land area of any plant or animal food source, while at the same time producing calories. Soybeans contain about 40 per cent protein and about 20 per cent fat. The amino acid distribution of soybean protein is nearly that recommended by FAO for maximum protein utilization. The soybean also has the ability to provide its own nitrogen requirements through symbiotic nitrogen fixing bacteria, Rhizobia, and to leave a generous amount of nitrogen in the soil for a subsequent crop. This itself is a key factor in the current period of rising fertilizer prices and becomes a major consideration in the development of cropping systems keyed to limited inputs of fertilizers and other chemical agents.

Currently soybeans are widely used directly as human food only in Asia. The basic processes for conversion of whole soybeans to human foods are known but intensive research and development on processes and nutritional studies are needed to provide information needed to encourage low-income groups to accept soybeans as part of their normal diet.

Soybean yields in developing countries average less than one-half the potential, particularly in tropical and subtropical areas. Successful cultivation of soybeans in those areas depends upon a combination of high-yielding varieties, resistance to insects and diseases, proper cultural practices, and determination of their technical and economic place in cropping systems. The nutritional potential of soybeans can be realized on a worldwide scale, only through a concerted attack on the problems of soybean production and use.

B. Project Objectives as Stated in the Contract

The general objective of the project, as stated in the contract, is to "perform a research and development program directed toward the development of improved varieties of soybeans." The objective is elaborated upon in the specific statement of work that provides that the contractor will undertake:

1. Development of technical assistance and research linkages in tropical soybean variety improvement, cultural practices, inoculation, pest control, and harvesting, processing, and storage methods;
2. Research to screen the soybean for broad adaptation to the tropical soils, tropical climates, and insect and disease resistance;
3. Research on isolating and testing Rhizobium strains for their effect on fixing nitrogen and increasing yields;
4. Assistance and backstopping LDC institutions in conducting cooperative adaptive research in soybean improvement;
5. Programs of formal and practically oriented training and guidance in soybean research;

6. Demonstration in selected countries of Latin America, Africa, and the Far East, of the University of Illinois process for rapidly rendering soybeans available in the village and at the home level as a human food in an effort to determine what regional modifications the process may require in order to make the product acceptable to the local palate and usable in soy-based foods; and

7. To make available improved soybean varieties and products to LDC's and cooperating research institutions for trial under the individual conditions of the developing countries.

C. Continued Relevance of Objectives

Experience gained in the first two years of the contract reaffirm the soundness of the general objective. Constraints to the production and use of soybeans can be reduced only by a program of basic and adaptive research. There is widespread interest among governments, institutions and scientists in tropical, subtropical and temperate countries in cooperation and participation in research and development activities.

Working against the full realization of the primary objective of the research contract are the limiting factors of time and funding. These constraints were discussed in the first Annual Report, yet bear repeating here:

"The level of funding is adequate for research and development of research linkages in the following areas: soybean variety development, soybean entomology and pathology research with emphases that complement variety development research, and evaluation of varieties for nutritional value and cooking qualities. Research on all aspects of production and on marketing and storage cannot be carried out with current funding. Research on soybean foods and processing methods that is not directly related to variety improvement is desperately needed but should be supported by separate funding.

"The areas of research specified in the current statement of work that cannot be adequately performed with resources available under this contract and budget are the following:

1. Development of technical assistance and research linkages in cultural practices, inoculation, harvesting, processing, and storage methods (parts of objective 1).

2. Research on isolating and testing Rhizobium strains for their effect on fixing nitrogen and increasing yields (objective 3).

3. Demonstrations of the University of Illinois soybean processing methods (part of objective 6)."

Consequently the workplan for the period covered by this report was carefully drawn to concentrate on the activities that could be adequately funded and staffed. Significant additions were made to the contract staff in the area of plant protection (insects and diseases). An associate director, stationed at the University of Puerto Rico-Mayaguez Campus, was added on a one-quarter time basis to strengthen program coordination in planning, administration and operation. Work continued in soybean variety development, information systems, insect collections and food science and was expanded in insect pest management, and soybean pathology.

D. Accomplishments

The results of the current year's activities are generally reported with reference to the goals set forth in the "Plan of Work" contained in the 1973-1974 report. Appendices I-VII contain detailed information on research in the major areas of concentrations.

1. Soybean Variety Development. The major objectives of variety development are high yield and high protein per unit of land area, suitable photo-period response, resistance to limiting diseases and insect pests and wide adaptability in tropical and subtropical environments. Work in variety development for the current year focused on 1) evaluation of results of the 1973 plantings, 2) continuation of standard variety experiments in differing agroclimatic regions, 3) collection of seeds of promising local varieties for use in future experiments, 4) incorporation of promising plant selections in a crossing program in Puerto Rico in cooperation with 211(d) activities of the University of Illinois and the University of Puerto Rico, and 5) evaluation for protein and oil of germplasm having favorable agronomic characteristics.

Twenty-six of the 33 cooperating countries returned experimental data from 58 of the 90 trials distributed during the first year. The highest yield reported was 4911 kilograms per hectare (72.2 bushels per acre) from a Pakistan trial. Five other locations reported yields greater than 4000 kg/ha (58.8 bu/A) and 11 locations reported yields between 3000 and 400 kg/ha (44.1 and 58.8 bu/A) Only eight locations reported maximum yields of less than 1000 kg/ha (14.7 bu/A). The mean of the highest yielding variety at each location was 2285 kg/ha (33.6 bu/A) and the range was from 281 to 49 11 kg/ha (4.1 to 72.2 bu/A). Days to maturity of the highest yielding varieties at the several locations ranged from 62 days for a local variety in Thailand to 203 days for variety Semmes grown in Jordan, with the mean being 90 days. Latitudes ranged from 35° N in Afghanistan to 30° S in Lesotha with a mean for all trials of 14°. Altitudes ranged from 9 meters to 1803 meters with the mean at 342 meters.

In March 1974 material for the second set of experiments was distributed to cooperators for early planting. The number of varieties was reduced from 20 to 15, including the 12 best performing varieties in the preceding year and three new varieties. Some cooperating LDC's desired short season soybean varieties to fit local environmental conditions or cropping systems. In response to these demands two sets of varieties were established, an early set of varieties from U.S. maturity groups 00 through group V, and a later maturity set of varieties from U.S. maturity groups III through IX.

Cooperators were encouraged, in years I and II to substitute local varieties for standard varieties included in the trial. Seeds from promising local varieties have been collected for possible use in future experiments. The seed has been sent to INTSOY and forwarded to Puerto Rico. There it will be increased as part of the interinstitutional collaborative program.

A number of varieties from Australia, Brazil, Colombia, India, Nigeria, Rhodesia, the United States and Viet Nam are currently under evaluation in Puerto Rico. Plant selections from these varieties showing promising characteristics for tropical and subtropical environments will be incorporated into the breeding program. Characteristics being evaluated include yield potential, plant height, short-day insensitivity, resistance to shattering, pod height and resistance to insects and disease.

Of the first year's experiments, seed samples from 34 of the 58 responding locations were returned for protein and oil analysis. An additional eight locations determined protein and oil content locally. An encouraging indication of cooperating country interest in oil and protein analysis is the fact that seed samples from 27 locations in the second year's experiments have already been returned for analysis.

A detailed description of the Standard Varietal Experiment Program is found in Appendix I.

2. Taxonomic Information Retrieval System (TAXIR). TAXIR is a system for coding germplasm information published in USDA/ARS Regional Soybean Laboratories manuals on punchcards for quick retrieval. Information derived from the varietal experiment program and the breeding program is coded and integrated into the system. The level of support to TAXIR from the research contract was limited to a one-half time research associate and an allocation of computer time, with the major portion of support for the system being derived from other sources.

Presently there are approximately 3700 entries in the TAXIR data bank. Each entry can be scored with a maximum of 157 characters. Further information on the TAXIR system may be found in Appendix II.

3. Insect Control and Entomological Studies. The objective of the entomology research program is to devise control strategies that encourage economically high yields and to aid research scientists involved in solving soybean-insect problems.

Personnel changes were made during the current year to increase the ability of the Entomology Research Team to become more responsive to major problems in the area of international soybean insect research and to begin developing insect pest management programs for tropical and subtropical conditions. A new position, Entomologist-Pest Management, was added to the contract staff. This position was filled effective October 28, 1974. Concurrently the position of Entomology Technician, which supported the Soybean Insect Petrieval Information Center (SIRIC) was discontinued. The Soybean Faunal Analyst, whose chief responsibility is the International Reference Collection of Soybean Arthropods (IRCSA), took on the additional responsibility for coordinating the international dimensions of SIRIC.

Excellent cooperative relationships have been established by the Pest Management Specialist with the INTSOY plant pathology group, both of which work in close association with the variety experiment and breeding programs. Together they have initiated experiments in cooperation with scientists in Puerto Rico on soybean mosaic. The Pest Management Specialist initiated adaptation of the pest management guidelines developed at the University of Illinois to see if they can be applied to conditions in Puerto Rico. This is a first step in the adaptation of the guidelines for LDC's in the tropics and subtropics.

Significant assistance was given to soybean researchers internationally and domestically through the international reference collection (IRCSA) and the insect research information center (SIRIC). During the reporting year 1460 specimens representing 358 species were identified by IRCSA, detailed identification reports were provided and pertinent literature was supplied to nine major domestic and international soybean pest management research programs. The geographical coverage of the collection expanded with specimens from Australia, Ethiopia, Nicaragua, Peoples' Republic of China, and the Sudan received during the year.

Additions were made to SIRIC to bring the total number of titles, abstracts, or copies of references on soybean arthropods to 12,500. The net addition of 2,500 titles during the reporting year is less than one-half the number of additions made in the previous year, reflecting the discontinuance of the technician position that serviced SIRIC.

Activities of the soybean entomology research group are reported in greater detail in Appendix III.

4. Soybean Pathology. The objectives of the research effort in soybean pathology are: (i) to identify the limiting soybean diseases in the tropics and subtropics, (ii) to generate basic information about soybean pathogens that can be used to predict their spread and importance, (iii) to devise methods to control or reduce the impact of diseases, and (iv) to assist in breeding tropically adapted soybean cultivars with resistance to important pathogens.

Work in soybean pathology was formally integrated into the research contract in the report year with the assignment of specialists in bacterial, fungal, and viral diseases. Two scientists filled the one full-time position allocated to pathology.

Progress was made in systemitizing the identification of soybean diseases in the tropics and subtropics through the international varietal trial program. Space was provided on data sheets that accompanied the second year's trials to describe symptoms of viruses occurring in each trial. Although few cooperators are equipped to accurately diagnose virus diseases of soybean plants, more accurate information on the occurrence of virus diseases, and diseases caused by other agents, is expected.

The Work Plan for the report year envisioned preparation of a compendium of soybean diseases. INTSOY pathologists are nearing completion on three literature summary publications: (i) an international soybean disease compendum, supported by INTSOY, the American Phytopathology Society and the American Soybean Association, (ii) an annotated bibliography on soybean diseases, supported by INTSOY and the University of Illinois' College of Agriculture, and (iii) a bibliography of soybean virus literature, also supported by INTSOY and the University of Illinois' College of Agriculture. These publications will become available during the next report period.

Work anticipated on screening soybean varieties and germplasm for reaction to white-fly transmitted viral diseases was not integrated into the research contract. Existing relationships with scientists at the University of Puerto Rico provided a limited amount of information that may be expanded in the future. Research was initiated on (i) the identification and spread of certain virus diseases, (ii) the role of seedborne microorganisms in seed deterioration and death, (iii) the interaction of soybean cyst nematodes and the charcoal rot fungus on soybeans, and (iv) the control of soybean rust.

Appendix IV provides additional information on the activities in soybean pathology.

5. Food Science. In addition to the regular research program food science personnel conducted a review of existing literature citing processes and concepts which could be expected to produce interesting, acceptable, and adaptable products for use on home or village industry scale. The report includes a review of publications on cooking methods for home and village use, important abstracts on soy flours and soy beverages, and a bibliography of sources. This review is included as Appendix V and is available separately from INTSOY.

Research was conducted in the following areas:

I. Observations were made on the use of sodium and ammonium bicarbonate as tenderizing agents during the soaking and/or blanching steps of processing prior to canning.

II. Studies were carried out on the rate of water uptake and the development of tenderness by several varieties of soybeans under different soak/blanch conditions. Aqueous solutions with and without bicarbonate were used for soaking/blanching.

III. Protein efficiency ratios (PER's) were determined on 11 prototype foods mady wholly or partly from "field" varieties of soybeans.

IV. Initial studies were made on development of concepts and equipment for village level processing of soybean based foods.

V. A study was made on effect of corn milling techniques on drum-dried corn-soybean weaning foods.

Data and detailed information are shown in Appendix VI. A summary of each major project and sub-project follows:

I-A - Use of bicarbonates for processing soybeans.

1. Both sodium bicarbonate and ammonium bicarbonate can be used to tenderize soybeans before canning. The effect of bicarbonates depends upon their concentration and the processing steps during which they are used.

2. Use of either of the bicarbonates only during soaking is more effective than only during blanching. Treatment only during soaking is as effective as treatment during both soaking and blanching.

3. The tenderness of the blanched soybean varies with the bicarbonate concentration used. Maximum tenderness was obtained with use of the highest concentration of the bicarbonate. However, soybeans treated with distilled water were also very tender.

4. Taste panelists detected no significant difference in flavor or off-flavor as a result of the use of bicarbonates. Soaking appeared to be the processing step which most effectively tenderized the soybeans as observed by taste panelists and as measured by shearpress.

5. The use of bicarbonates during soaking and/or blanching increased the pH of the brine in which the soybeans were canned and higher concentrations of bicarbonate resulted in a higher pH. The pH of all products was in the acceptable range, i.e., 6.1 to 6.8, even though the bicarbonate solutions used always had a pH of 7.5.

6. During storage the canned soybeans became less tender as measured by Lee Kramer shearpress. The decrease in tenderness was greater at higher storage temperatures. When bicarbonates were used, the decrease in tenderness was less than when bicarbonates were not used.

7. Taste panelists did not detect any changes in tenderness, flavor or off-flavor during storage.

8. The pH of the brine changed during storage. In general, the brine tended to approach the pH range 6.1 to 6.3. The change of pH was more rapid at higher temperatures.

I-B - Use of mixtures of sodium and ammonium bicarbonates for soaking or blanching soybeans.

1. No synergistic effect was detected when ammonium and sodium bicarbonate mixtures were used to process soybeans.

II-A - Water uptake by soybeans.

Since soaking was found to be the processing step which most effectively tenderized soybeans, as observed by taste panelists in the experiment on bicarbonates further work was indicated on water uptake. This experiment was designed to find the fastest and best conditions for highest uptake of water.

1. Temperature was the most important factor which determined the rate of water uptake by soybeans. A plot of rate of water uptake versus temperature indicates a biphasic curve with a sharp break at approximately 60°C. Up to 60°C the rate of water uptake increased, while between 60 and 90°C the rate of water uptake was nearly constant.

2. The amount of water uptake was lowered by temperature and by the presence of bicarbonate in the solution in which the beans were placed.

3. There was no significant difference in the amount of water uptake of year-old and freshly harvested Kanrich soybeans.

4. The percentage of water uptake of Kanrich beans was less than the percentage of water uptake of Wayne beans. This effect is probably due to difference in size of the beans.

II-B - Effect of variety upon tenderness of cooked soybeans.

1. The tenderness of cooked soybeans of all varieties was increased by longer soaking times and use of bicarbonate in the soak and blanch solution.

2. Varieties exhibited substantial differences in tenderness (shearpress) after cooking. However, no variety was consistently more tender than the others for all solutions used or under all soak conditions.

3. No method has yet been found which allows prediction of tender varieties of soybeans.

III - Nutritional evaluations.

1. Mixtures of soy-cereal in simple combinations such as 1-1 or 2-1 resulted in increased PER's compared with whole soybeans.

2. Addition of methionine improved the PER's of soy-cereal mixtures.

3. Drum-dried soy-banana mixtures had a low PER. The low PER probably resulted from interaction of amino acids and reducing sugars. Addition of methionine to soy-banana mixtures, did not improve the PER.

IV - Village-level processing of soybean based food products.

The concepts for preparing highly nutritious whole soybean based products that can be prepared in 30-40 minutes are being developed and appear to be very promising. These concepts require that the whole soybean be broken or ground either before or after cooking or both. Thus, small size or pilot plant type mills are needed and a list of companies who could supply such equipment was developed. Only a few electric powered mills are available that appear suitable and are $2,500.00 or below in cost. These mills will be investigated and a survey of hand-powered mills will also be made. It is also considered that it may be necessary to develop certain specific types of milling equipment.

V - Drum-dried corn - soybean weaning or breakfast food samples.

In general the conclusions reached from this study indicate that:

1. Pre-gelatinization generally improved flavor but slightly reduced color acceptability.

2. Samples containing whole ground corn were generally inferior to the other products containing the corn fractions. This is most interesting and unexpected because texture acceptability did not relate to fiber content in the final samples.

This study clearly indicates that further work is needed to determine the best milling practice for corn that is used in combination with whole soybeans. Apparently certain fractions of the hull and perhaps the germ of corn do not tenderize and break down during milling, cooking and drying. This results in a texture that tends to contain many particles which gives a highly objectionable organoleptic texture characteristic. Similar studies should be made on essentially all of the different cereal-soybean drum-dried weaning foods.

E. Training, Workshops and Communication

Training of foreign country research workers was conducted by INTSOY scientists in several ways: site visits to cooperating institutions; visits to UIUC and to the University of Puerto Rico, Mayaguez Campus, and research stations; a major regional workshop for soybean researchers; initiation of the INTSOY newsletter and publication of three issues; and two of the five publications in the INTSOY publication series. The flow of visitors continues to increase reflecting the increasing recognition of the potential of soybeans as a means of alleviating the protein-calorie deficiency problems of tropical and subtropical areas.

A second major regional conference was conducted in Addis Ababa, Ethiopia in October 1974. With sponsorship by INTSOY, the Ethiopian Institute of Agricultural Research and support of AID more than 80 soybean scientists from Africa, the Middle East and South Asia gathered for four days of discussion and observation on the production, protection and utilization of soybeans in the tropics and subtropics. Two volunteered papers and 18 separate country reports by conference participants provided valuable information on the growth of interest in, and work on, soybean development in the region. The Proceedings were published in March 1975 as Number 6 in the INTSOY Publication Series.

A planning committee for a third regional soybean conference for Asia and Oceania has been formed and is active. Co-sponsors are being contacted, the program is being developed and alternative dates are being considered. The Asian Vegetable Research and Development Center has agreed to be a co-sponsor and support of the Government of Thailand is being sought. The conference will probably be held in late February 1976.

Three issues of the INTSOY Newsletter were distributed during the report year, in August and November 1974 and February 1975. The fourth issue will be distributed in May. The Newsletter mailing list is increasing -- approximately 900 persons or institutions receive each issue -- with about one-half the readership outside the U.S.

Six publications have been distributed in the INTSOY Publications Series. They are cited fully in Appendix VIII and their titles are:

Number 1 - Selected Literature on Soybean Entomology

Number 2 - Proceedings of the Workshop on Soybeans for Tropical and Subtropical Conditions

Number 3 - A Case Study of Expeller Production of Soybean Flour in India

Number 4 - Soybean Processing in India: A Location Study on an Industry to Come

Number 5 - Potential Production of Soybeans in North Central India

Number 6 - Soybean Production, Protection and Utilization - Proceedings of a Conference for Scientists of Africa, the Middle East and South Asia

Numbers one, two and six resulted directly from work under the contract. Numbers three, four and five add important studies to the Series although the funds for their printing costs did not come from the research contract.

Response to these publications from individuals and libraries has been excellent. Numbers one and three have had a second print run.

Of the two sets of proceedings, Number two was prepared and distributed by the University of Puerto Rico, Mayaguez Campus and Number six was prepared and distributed by the University of Illinois at Urbana-Champaign.

Staff from the departments of food science, agricultural economics, agricultural engineering and agronomy participated in conducting a short course entitled "Soybean Processing for Food Uses" sponsored by USDA's Office of International Training. Thirteen participants from 11 countries, most of them financed by AID, spent about two and one-half weeks in late March-early April, 1975 in lecture/laboratory sessions on the Urbana Campus, followed by a 10-day field trip to processing plants, equipment manufacturers and research laboratories. The course will be repeated in 1976.

Planning is in process for a second short course to be given during the Summer of 1975. Entitled "Technical and Economic Aspects of Soybean Production," the course will draw from agricultural communications, agricultural economics, agricultural engineering, agronomy, entomology, and plant pathology and from outside sources. Two major field trips will be taken. Individual research projects will be conducted by each course participant. Enrollment projections indicate up to 19 individuals from 17 countries may enroll.

F. Travel

Travel was generally limited to locations conducting standard varietal experiments, to countries engaged in or selected to work in plant protection and food-use activities, to recognized international centers, to centers of information on soybean breeding, protection and development and to selected international meetings pertinent to the research program. Trip reports are on file in AID/W and in the USAID's of countries visited.

A summary of travel, commenting on the objectives and accomplishments of each trip,is included in Appendix VII.

G. Complementary Activities

Stressing an interdisciplinary, functional approach to soybean development, the INTSOY program, and this research contract, benefit from planned, complementary effects from program activities funded from several other sources. The INTSOY program relies heavily on AID support. In this report year, in addition to funds provided by this research contract, funds have been made available by AID under:

1. Grant AID/CM/ta-G-73-49: A 211(d) grant to provide institutional response capability in soybean breeding. Based at UIUC with a significant field component at University of Puerto Rico, Mayaguez Campus.

2. Grant AID/CM/ta-G-73-50: A 211(d) grant to provide institutional response capability in plant protection. Based at University of Puerto Rico, Mayaguez Campus.

3. Basic Ordering Agreement AID/CM/ta-BOA-73-30: A general agreement to provide a wide range of technical assistance services to requesting USAID Missions under issuance of specific task orders. During the report year task orders were underway and/or completed in Guyana, Uruguay and Peru.

4. Basic Ordering Agreement AID/CM/ta-BOA-1109: Superceding BOA-73-30 while continuing mandate to provide technical assistance services in soybean development. During the report year task orders were written for Bangladesh (completed) and Peru.

5. Grant AID/ta-G-1151: A grant to support the second regional workshop for soybean scientists from Africa, the Middle East and South Asia, October 1974.

Other sources have provided support to the INTSOY program that had direct or indirect benefits to the objectives of the research contract.

1. Grant 72009 made by the Rockefeller Foundation to UIUC specifically for support of INTSOY provided needed funds 1) for outfitting an INTSOY field office for seed handling and other functions on the College of Agriculture South Farm, 2) for laboratory equipment to support the staff in plant pathology and entomology added to the research contract staff, 3) for program developmental work in soil microbiology and Rhizobium inoculation not adequately provided by the research contract, 4) for equipment, vehicle and technician support to the plant breeding activities in Puerto Rico not adequately provided by either the research contract or the 211(d) grants, 5) for initiation of a cooperative study of soybean storage in tropical and subtropical conditions undertaken by the departments of agricultural engineering at UMC and UPR/M; and for research assistant and technical support to research contract staff.
2. A contract recently signed with the Food and Agriculture Organization of the United Nations commits INTSOY resources in support of a national soybean development program in Sri Lanka. Assistance and direction will be given to the development of an integrated program that will eventually encompass production, protection, pricing and marketing and industrial and food uses of soybeans.

In addition the College of Agriculture has committed a substantial percentage of its contract research reserve allocation to a variety of activities that support the research contract and the INTSOY program in general.

H. Administration and Budget

Expansion of research contract staff in the fields of plant pathology entomology and food science was accomplished. Some advances were also made in the vital area of support staff, without which no research effort can succeed. Personnel employed under the research contract, exclusive of casual labor, the specialization and per cent time include:

Administrative and Professional

1.	William N. Thompson, Director, INTSOY	50%
2.	Raul Abrams, Assoc. Director, INTSOY and Sr. Agronomist	25%
3.	Thomas A. McCowen, Assistant Director	25%
4.	D. K. Whigham, Production Agronomist	75%
5.	Carl N. Hittle, Plant Breeder	25%
6.	Robert A. Dunker, Assistant Agronomist	100%
7.	Leslie K. Ferrier, Food Science-Chemistry	75%
8.	Alvin I. Nelson, Food Science-Processing	25%
9.	Michael Irwin, Entomology-Pest Management	100%
10.	George K. Godfrey, Entomology-Soy Faunal Analyst	50%
11.	James B. Sinclair, Plant Pathology-Fungal Diseases	25%
12.	Robert M. Goodman, Plant Pathology-Viral Diseases	75%

Support Staff

1.	Helen Burnsmier, Research Assistant, Agronomy	100%
2.	Christine Newell, Research Associate, Agronomy	50%
3.	Donna Rosborough, Research Assistant, Food Science	100%
4.	Douglas Prensner, Technician, Food Science	50%
5.	Prateung Sangawongse, Res. Associate, Pl. Pathology	100%
6.	Deanna Taeger, Clerk Typist-Administration	100%

A summary of the yearly expenditures for the period April 1, 1974 - March 31, 1975 is shown below in Table I.

Table I. Summary of Expenditures by April 1, 1974-March 31, 1975

Major Line Items		
1. Salaries and Wages		129,860
a. Home Office Professional	91,765	
b. Support Staff	34,300	
c. Wages	3,795	
2. Fringe Benefits		11,315
3. Indirect Costs		81,640
4. Travel & Transportation		25,885
a. U.S. Travel	9,965	
b. International Travel	15,920	
5. Other Direct Costs		5,900
6. Equipment, Materials & Supplies		26,755
		281,355

I. Plan of Work, April 1, 1975 to March 31, 1976

Work under the Contract is proceeding according to an approved work plan for FY 1975. The following is the Plan of Work and Budget for the contract year beginning April 1, 1975 to March 31, 1976, the final year of the Contract as it is presently written. New research needs are regularly being uncovered as the work of the project advances. In this the third year of operations, activities will expand on the assumption that continuing funds will be made available through some mechanism to carry forward the work.

I. Staff and administration

Major additions were made in the professional staff in the 1974-1975 contract year. While it would be desirable to add a number of positions to the professional staff for the 1975-1976 contract year, emphasis will be on augmenting the support staff to provide the technical, clerical and hourly assistance necessary to effectively pursue contract research goals. The following support staff will be added to the program for 1975-1976 to those previously authorized levels:

1. Research Assistant - Soybean Pathology - 1.0 fte
2. Research Assistant - Food Science - .5 fte
3. Research Assistant - Agricultural Entomology - 1.0 fte
4. Secretarial Assistance - Administration, Agronomy and Plant Pathology - 2.0 fte

II. Soybean variety development

The major objectives of variety development are high yield and high protein per unit of land area, suitable photoperiodic response, resistance to limiting diseases and insect pests, and wide adaptability in tropical and subtropical environments.

Work in soybean variety development for the year beginning April 1, 1975, will include the following:

1. Publication of the evaluation of results of the 1973 planting under uniform variety experiment program consisting of 20 varieties, and in some cases, local varieties. Analysis was completed in March, 1974.

2. Evaluation of results of the 1974 plantings under the uniform variety program. The 1974 trials included 15 varieties - the 12 best performing varieties in 1973 plantings plus three new varieties - planted in 60 countries and at 139 locations. Cooperating scientists were requested to substitute two local varieties at each location.

   The analysis will include comparisons of yield, oil and protein content, length of time to flower and to mature, plant height, lodging shattering, seed weight, nodule count and weight, pod number and disease scores. The date for reporting of 1974 data by cooperators has been set at July 1, 1975. A publication reporting on the 1974 variety of experiments will be completed. Data for each experiment will be summarized and distributed to cooperating scientists.

3. Standard variety yield trials in different agroclimatic regions will be conducted to further evaluate varieties showing promise in previous experiments and to test promising new varieties.

   The 1973 data indicated that there should be two sets of standard variety trials, an early maturing set and a late maturing set of varieties. The early maturing varieties, a small percentage of the total number, are useful in such countries as Afghanistan, Iran, Bhutan, Pakistan, Indonesia, etc. The early maturing set includes varieties in the U.S. maturity groups 00 through V. It is anticipated that the early maturing groups will be tested at approximately 25 locations in 1975. The more numerous late maturing package includes varieties from U.S. maturity groups III through IX and it is anticipated that at least 150 locations will receive the late maturing set. In all, the number of countries that will be involved in the variety experiment program during 1975 will increase from 60 to 75-80, some of which will have more than one uniform variety trial in order to evaluate results during the dry and rainy season periods in the different environmental areas of the countries.

4. Seed from the 1973 plantings and other accessions are under increase in Puerto Rico. Seed from 1974 plantings which show promise will be collected for use in future varietal experiments. Seeds of the most promising local varieties will be increased in Puerto Rico a part of the interinstitutional collaborative program. In 1974, 46 varieties from 10 countries or centers were available for increase in Puerto Rico.

5. Soybean selections showing promise and characteristics for tropical and subtropical environments will be incorporated into the supportive crossing program in Illinois and Puerto Rico in cooperation with the 211(d) activities of the University of Illinois and the University of Puerto Rico. The 211(d) program is concentrating on development of breeding lines and conducting initial evaluation trials. Yield potential, plant height, photo-insensitivity, shattering resistance, pod height, insect and disease resistance and food acceptability are characteristics which are compared in the crossing program. Collection of germplasm from existing breeding programs throughout the world will continue.

6. An experiment will be initiated to evaluate the effects of temperature and natural radiation on soybeans grown at different altitudes at the same latitude. Three to six uniform variety trials will be planted at altitudes ranging from sea level to 8000 feet. Ecuador has indicated willingness to be the location of this experiment.

III. Taxonomic Information Retrieval System (TAXIR)

Support to TAXIR will continue in the limited form of a research assistant-data processor and allocation of computer time. The research assistant will be used in support of the production agronomist and the plant breeder and will also process information derived from the breeding work under 211(d). Information generated from the above sources will be integrated into the TAXIR system, the major support for which is derived from other sources.

IV. Insect control and entomological studies

Work by the entomology group will emphasize pest management studies in Puerto Rico and other locations, cooperation with work in plant breeding and plant pathology in developing resistant lines, and extension and use of information gathered in two computerized information systems, the Soybean Insect Research Information Center (SIRIC) and the International Reference Collection of Soybean Arthropods (IRCSA).

The pest management specialist will:

1. Assemble and bioassay lines resistant to defoliators in cooperation with the 211(d) plant breeder.

2. Cooperate with soybean virologist on experiments to determine relationships between the spread of insect transmitted viruses and vector behavior in soybean fields.

3. Begin site identification for intensive collection activity of selected locations in various ecological zones preparatory to applying the Illinois Pest Management Guidelines on an intensive investigation from which pest management models can be developed for different ecological areas.

4. Develop training and identification materials.

The soybean faunal analyst will:

1. Conduct biosystematical research on lepidopterous pests of soybeans.

2. Develop a series of identification guides for insects associated with soybeans including pests, vectors, parisitoids and predators. The guides will be prepared on a geographic scale with illustrations, descriptive characteristics, types of damage done, distribution and methods of control.

V. Soybean pathology

Work in soybean pathology will emphasize cooperation with pest management work in entomology and plant breeding activities of the research contract and the 211(d) program activities in Puerto Rico, and will commence activities dealing with seed pathology.

The soybean virologist will:

1. Purify and characterize in detail the nature of the virus-like whitefly-transmitted pathogen causing yellow stunt mosaic (Rhynchosia mosaic) disease of soybeans in Puerto Rico.
2. Devise procedures for screening of soybean lines for disease resistance or tolerance. This work will be in cooperation with the pest management specialist, the 211(d) plant breeder, and the University of Puerto Rico 211(d) pathologist.
3. Cooperate with the pest management specialist on experiments to measure the spread of insect transmitted viruses in relationship to vector movement.
4. Participate in assembling world literature on soybean virus and other diseases in such a way as to facilitate dissemination of citations and summaries of results to soybean scientists.

The soybean fungal and bacterial specialist will:

1. Identify the various seed-borne microorganisms and pathogens associated with soybean seeds from selected countries.
2. Determine the pathogenicity of the various isolated organisms and their role in reducing germination and emergence of soybean seedlings.
3. Study the sites of primary infection by the various pathogens in the soybean seed.
4. Direct preparation of an annotated bibliography of soybean diseases.
5. Cooperate with soybean rust pathologist in exploring with AVRDC and other research organizations possibilities for cooperative research on soybean rust.

VI. Food science

Work in the area of food science and nutrition will be expanded to include:

1. Nutritional evaluation on selected soybean products using procedures developed in 1974. Previous limited nutritional studies indicated that certain soybean products were superior to others in PER. Various soybean cereal products exhibited substantial differences in nutritional values. Studies will be made to determine the effect of processing variables on PER and to determine desirable soy-cereal (soy-wheat, soy-corn

and soy-rice) combinations as well as improved drying techniques. Evaluation will include acceptance tests as well as PER and amino acid determinations.

2. Studies of effects of varietal differences of soybeans on rehydration and cooking quality. Initial studies suggest the possibility of differences among varieties with respect to cooking time for optimal tenderness. A careful examination and evaluation of commercial varieties and exotic and vegetable strains of soybeans will be made. Identification of varieties or strains of soybeans will be made. Identification of varieties or strains of soybeans which require significantly less cooking time will be reported to the plant breeding group to assist in developing varieties requiring less energy expenditures to process for human consumption.

3. Development of concepts for preparing whole soybean food products for use in home and village industry in developing countries. The Illinois procedure previously developed for preparation and processing of whole soybeans will be used as the model. The first step will be to inactivate the enzyme systems and growth inhibitors with moist heat using simple or readily available equipment and techniques. This will be followed by simple milling or other treatments to prepare a variety of products, liquid and solid, that could be produced on a home or village level. Eventually work will be directed toward developing suitable processing methods and equipment that can be used in small village industry.

VII. Other resources for contract related activities.

In addition to the activities directly funded by the research contract, professional interaction takes place with, and complementary benefits derive from, other activities within the total INTSOY program. For example:

1. A one year grant in the amount of $100,000 was made by the Rockefeller Foundation to finance activities, mostly of a support nature, which are not adequately covered under the AID research contract or in any of the other AID funding arrangements. As part of the grant, the Departments of Agricultural Engineering of UPR/Mayaguez and UIUC have commenced a study designed to:

   i. Determine soybean seed storage moisture contact requirements to maintain viability for relatively short storage times without ambient temperature control.

   ii. Evaluate various seed storage containers for protection against moisture content change during storage at farm and village level.

   iii. Investigate the need for raising the moisture content of stored soybean seed to minimize damage in handling and planting operations.

Other areas, primarily plant protection and production improvement, have received some support funds from the grant. With the termination of the grant, in late summer 1975, alternative funds will have to be identified as the level of support to the research contract and the total program will be greatly diminished.

2. An AID Basic Ordering Agreement was in force throughout the contract year to provide technical services through the mechanism of task orders in the areas of development of improved varieties of soybeans, their processing, utilization and marketing as foods and supporting cultural practices for production. Staff members who have served on one or more of the four task orders in effect during the year have developed important professional contacts and have arranged for interchange of seed, insect species, literature and, very importantly, ideas.

3. Repeated reference has been made to the plant breeding work of the 211(d) program and its interfacing with the research contract. With the addition of Dr. E. H. Paschal II to the 211(d) activity, with duty station in Puerto Rico, the substantially increased activity in breeding of high yielding varieties with resistance to pests and diseases and possessing desirable nutritional and cooking qualities can take place.

4. Of increasing importance will be the interaction between the plant protection group and the 211(d) program at the University of Puerto Rico, Mayaguez Campus. This program is complementary to the plant breeding effort and focuses on disease control and related insects and cultural practices of soybeans and other food legumes. Cooperative work has been described in Section V.

VIII. Training workshops and communications

The practice of training foreign country research workers, by demonstration, lectures and seminars, in the several subject matter areas by INTSOY scientists doing site visits to cooperating institutions will be continued in the third year of the contract.

A third major research and production workshop will be held for soybean workers from Asia and Oceania. The conference will be held in early 1976 at a site to be determined. The workshop will include aspects of soybean production, protection and utilization much as the workshops held in Puerto Rico in February 1974 and Ethiopia in October of 1974. General coverage of those topics intended to be of interest to all participants will be supplemented with symposia in which specific subjects such as soybean rust, seed quality, photo-periodic response, etc. will be covered in greater detail. The workshop planning committee was formed in January, 1974 and is at work determining program content and site selection. The major costs of the workshop, e.g. travel for invited speakers, local conference costs, etc. will probably be made available by AID from GTS funds, as was the case with the two previous workshops. Some ancillary costs may be mde from contract funds, and INTSOY will be responsible for the planning and administration of the workshop.

The INTSOY Newsletter is being published on a regular basis and a substantial mailing list has been developed. During the third year of the contract the newsletter format will be refined, striving to produce an informative, informal and easily readible reference to interested soybean scientists.

IX. Travel

Travel of personnel will be limited to locations having direct applicability to the research contract. Travel will be undertaken to locations conducting, or under consideration for conducting, uniform varietal experiments to major international centers, to centers of information on soybean breeding, protection and development and to selected international meetings pertinent to the research program.

X. Budget

In translating the program of work into a budget statement some unexpended funds from 1974-1975 have been allocated among the several line items with heaviest concentration on support personnel, materials, supplies and other direct costs items.

Budget for Year III

Period and Amount

Line Item	Expenditures 4/1/73-3/31/75	Budget 4/1/75-3/31/76	Total Budget
1. Salaries & Wages	$213,970	$214,000	$427,970
2. Fringe Benefits	15,915	24,500	40,415
3. Travel & Transportation	44,805	55,100	99,905
4. Other Direct Costs	11,160	37,745	48,905
5. Equipment & Supplies	37,265	48,250	85,515
6. Indirect Costs	134,630	143,265	277,895
	$457,745	$522,860	$980,605

APPENDIX I

Soybean Variety Development

The soybean variety evaluation experiments continued to expand to new countries and environments during the second year of research. The number of entries was reduced from 20 to 15 as the less productive varieties were removed and some new entries were added. Twelve entries were retained from the 1973 tests and 3 new varieties were included. A modified system of data collection was introduced which improved efficiency of data collection and analysis. Field data books were prepared so data could be recorded directly in the field with a carbon insert for duplicate copies of the data. After completion of the experiment the original data sheets were returned to INTSOY and the cooperator retained the carbon copy. Detailed instructions for management and data collection were modified. The new system calls for data collection from each plot for days to flower, days to maturity, nodule number, nodule dry weight, plant height, lodging, shattering, number of plants harvested, pods per plant, grain yield, seed weight, seed quality and disease rating. Additional information for each location was requested to determine the environmental conditions, planting and harvesting dates, and pest problems of the test site.

Accomplishments

Return of data from 67% of the first cooperative trials. Experimental data were returned from 60 of the 90 trials distributed during the first year of the program (Table 1). Reasons for the lack of data from remaining trials include: late arrival of material due to shipment problems; environmental hazards such as flooding and insect damage; loss of material during shipment; and loss of seed germination due to conditions during shipment. In some cases the trial was stored until the next planting season since the optimum planting time had passed before the seed arrived. Twenty-seven of the 33 cooperating countries returned data.

Seed samples from 34 locations were returned for protein and oil analysis (Table 2). An additional ten locations determined the protein and oil content locally and returned the results to INTSOY. The Dickey-John Grain Analyzer was used for all seed analysis done at the University of Illinois.

Analysis of data and seed samples have been completed and the results have been distributed to contributing cooperators. A summary of the first variety evaluation experiments will be published in the INTSOY Publication Series.

Summary of Results

The highest grain yield reported during the first series of trials was 4911 Kg/ha (72.2 bu/A) from a trial tested in Pakistan. Five other locations reported yields greater than 4000 Kg/ha (58.8 bu/A) and 11 locations reported yields between 3000 and 4000 Kg/ha (44.1 and 58.8 bu/A). In contrast, eight locations reported maximum yields of less than 1000 Kg/ha (14.7 bu/A). The mean of the highest yielding variety at each location was 2285 Kg/ha (33.6 bu/A) and the range was from 281 to 4911 Kg/ha (4.1 to 72.2 bu/A).

Days to maturity of the highest yielding varieties at the various locations ranged from 62 days, for a local variety SJ-2 in Thailand, to 203 days for variety Semmes grown in Jordan. The mean number of days for maturity of the highest yielding varieties was 90. The same group of varieties had differences in plant height ranging from 22 cm for Hardee in Ghana and Davis in Thailand to

93 cm for Lee 68 in Pakistan. Mean plant height of the highest yielding varieties was 47 cm.

The range of latitude among the test sites was from 35° N in Afghanistan to 30° S in Lesotho with a mean for all trials of 14°. Altitude ranged from 9 meters in Costa Rica and Taiwan to 1803 meters in Afghanistan. The mean altitude for all trials was 342 meters.

The test sites were divided in "Environmental Zones" determined by units of 10° latitude and 500 meters altitude. "Environmental Zones" were designated to identify a reasonable limit to the environmental range of each zone. The variation within each zone for temperature, moisture and radiation is realized. The limits of the "Environmental Zones" and number of locations in each are:

Zone	Latitude	Altitude	Number of Experiments
I	≤ 10°59'	≤ 500 M	24
II	≤ 10°59'	501 - 1000 M	2
III	≤ 10°59'	> 1000 M	3
IV	11°- 20°59'	≤ 500 M	19
V	11°- 20°59'	501 - 1000 M	0
VI	11°- 20°59'	> 1000 M	0
VII	21°- 30°59'	≤ 500 M	5
VIII	21°- 30°59'	501 - 1000 M	1
IX	21°- 30°59'	> 1000 M	1
X	31°- 40°59'	≤ 500 M	1
XI	31°- 40°59'	501 - 1000 M	1
XII	31°- 40°59'	> 1000 M	3

≤ = less than or equal to

> = greater than

The top five yielding varieties at each location were evaluated for Zones I, IV and VII. In Zone I variety Hardee yielded high at 70% of the locations followed by: Hampton 266 A (43%); Williams (39%); Improved Pelican (30%); Davis (30%); and Adelphia (30%). Hardee was also a high yielding variety at 56% of the locations in Zone IV, followed by: Williams (39%); Improved Pelican (39%); Clark 63 (33%); and Davis (33%). In Zone VII Pickett 71 was the most consistent high yielding variety at 60% of the locations, followed by: Williams, Clark 63; Lee 68; Semmes, Bonus, and Harosoy 63 at 40% of the locations.

Correlation coefficients were computed among zone, yield, seed weight, days to maturity, plant height and planting date when the top five yielding varieties were combined for Zones I, IV and VII (Table 3). Those trials with a coefficient of variation (CV) greater than 30 were dropped from the comparison. A total of 33 trials were combined. The other Zones had an insufficient number of trials for comparison. Plant height was not correlated with Zone or seed weight and the month of planting was not correlated with seed weight or days to maturity at the 5% level of significance. Zones were negatively correlated

with seed weight and month of planting at the 1% level and with yield at the 5% level of significance. However, Zones were positively correlated with days to maturity at the 5% level, which indicates that as latitude increases, the number of days to maturity increased, but seed weight decreased as latitude increased.

Grain yield had a high positive correlation with seed weight. Yield was positively correlated with the number of days to maturity at the 1% level and plant height at the 5% level. Planting date was negatively correlated with yield at the 1% level. Seed weight and days to maturity are positively correlated at the 1% level of significance. As the number of days for maturity increased the seed weight and yield also increased. However, a larger percent of yield variation was due to seed weight rather than days to maturity. The positive correlation between days to maturity and plant height indicates that plants grew taller when the growing season was longer, probably because flowering was delayed due to longer days in different seasons and at different latitudes. The month of planting was negatively correlated with plant height at the 5% level, which indicates that the plant height was less when planted late in the year. Day length was also shorter late in the year in the Northern Hemisphere where most of the trials were tested.

Second Variety Evaluation Experiment

In March 1974 material for the Second Variety Evaluation Experiment was distributed to cooperators for early planting. A total of 136 trials were distributed to cooperators in 60 countries (Table 4) between March 1974 and February 1975. Fifty-five of those locations have returned data for analysis. Most other locations have indicated they will return the data in the near future. Forty-one locations have returned seed samples for protein and oil analysis.

The Second Variety Evaluation Experiment included the following varieties:

Jupiter	Bragg	Clark 63
Hampton 266A	Davis	Bonus
Hardee	Tracy	Williams
Improved Pelican	Forrest	Calland
Bossier	Hill	Semmes

The local cooperator had the opportunity to substitute two local varieties when they were available. A comparison between local and exotic varieties under the same management was very desirable.

Third Variety Evaluation Experiment

Many cooperating countries desire a short season soybean variety to fit local environmental conditions or cropping systems. The demand for more early maturing varieties in the trials has resulted in the establishment of two different sets of materials for testing. The early set of varieties include those from U.S. maturity groups 00 through group V as follows:

Altona	Corsoy	Clark 63
Swift	Beeson	Woodworth
Hark	Wells	Williams
Hodgson	Forrest	Calland
Amsoy 71	Columbus	Bonus

The late maturing set of material is similar to the Second Variety Evaluation Experiment and consists of varieties from U.S. maturity groups III through IX. The varieties included in the late set are:

Jupiter	Bossier	Clark 63
Hampton 266A	Davis	Woodworth
Hardee	Tracy	Williams
Improved Pelican	Forrest	Calland
Cobb	Columbus	Semmes

Maturity groups III, IV, and V are represented in both the early and late trials and there are six common varieties between the different trials.

Experiments 1, 2 and 3 have nine varieties in common. This data will permit analysis over years and environments in many countries. Determination of genotype x environment interaction will permit more accurate prediction of varieties which are adapted to given environments. Requests for cooperation in the Third Variety Evaluation Experiment have totalled 142 late and 33 early trials from 66 countries. Several cooperators of previous trials have not indicated their plans for future cooperation at this time. Many countries request trials for evaluation in different locations during the same season, and some evaluate varieties during both the rain and dry seasonal periods each year.

Varieties From Other Countries

Germplasm has been collected from many countries for evaluation and seed multiplication at the University of Puerto Rico. Those varieties which have desirable characteristics will be included in future evaluation experiments in cooperating countries. Varieties currently being evaluated in Puerto Rico are identified in Table 5. Plant selections showing promising characteristics for tropical and subtropical environments will be incorporated into a breeding program in cooperation with the 211(d) activities of the University of Illinois and the University of Puerto Rico.

Site Visitation by Staff

The INTSOY agronomists travelled extensively and visited trial sites in 17 countries (Table 6) this past year. Site visitations are extremely valuable to visually evaluate variety adaptation and crop management techniques used by each cooperator. Personal contact with cooperators facilitates easy communication in the future and permits the discussion of past trial results and future soybean research plans.

Table 1. Data returned from First Variety Evaluation Experiments

Region	Country	Location	Month Planted (1973 unless marked '74)
Africa			
	Somalia	Afgoi	March '74
	Ethiopia	Awassa	June
	Sierra Leone	Njala	September
	Egypt	Bahteem	July
	Ghana	Legon	May & October
	Lesotho	Ralinku	December
	Tanzania	Ilonga	March '74
		Njombe	December

Table 1 continued.

Region	Country	Location	Month Planted (1973 unless marked '74)
Asia			
	Pakistan	Swat	May
		Mansehra	May
	Malaysia	Serdany	October
	Vietman	Banmethuat	August
	Afghanistan	Kabul	May
	India	Jabalpur	July
		Pantnagar	July
	Taiwan	Shanhua	March '74
		Ping Tung	March '74
	Indonesia	Bogor	March '74
		Citayam	October
		Jogjakarta	July
	Philippines	Los Banos	June
		La Granja	May
	Thailand	Maejo	July & December
		Chiang Mai	July & December
		Tha Phra	June & November
		Lop Buri	August
		Suwan Farm	August
	Sri Lanka	Angunukulapalessa	June
		Gannoruwa	June & October
		Alutharama	May & October
		Maha Illuppallama	June & November
		Paranthan	November
		Ratmalagara	December
		Bandarawela	November
Mesoamerica			
	Belize	Central Farm	November
	Puerto Rico	Lajas	June
		Isabela	July & November
		Mayaguez	June & January '74
	Nicaragua	Leon	January '74
	Costa Rica	Taboga	July & November
		Hacienda Tempisque	May
	Mexico	Tampico	July
		Chiapas	August
Middle East			
	Jordan	Deir Alla	April '74
	Syria	Douma	April '74
South America			
	Colombia	Palmira	October
	Ecuador	Boliche	September
		Pichilingue	June
		Portoviejo	August
	Peru	La Molina	February '74

Table 2. Protein and oil analysis results available from First INTSOY Variety Evaluation Experiment.

Region	Country	Location	No. of trials
Africa			
	Ghana	Legon	2
	Egypt	Bahteem*	1
	Ethiopia	Awassa*	1
	Sierra Leone	Njala	1
	Tanzania	Ilonga	1
		Njombe	1
Asia			
	Pakistan	Swat	1
	Philippines	Los Banos	1
		La Granja*	1
	Thailand	Khon Kaen	2
		Maejo*	1
		Chiang Mai	1
		Suwan Farm	1
	Indonesia	Citayam	1
		Bogor*	1
	Taiwan	Shanhua	1
		Ping Tung	1
	Sri Lanka	Angunukulapalessa	1
		Maha Illuppallama	2
		Alutharama	2
		Gannoruwa	2
		Parathan	1
		Ratmalagara	1
		Bandarawela	1
Mesoamerica			
	Belize	Central Farm	1
	Costa Rica	Taboga*	1
	Mexico	Chiapas	1
	Puerto Rico	Lajas*	1
		Isabela*	2
		Mayaguez	2
Middle East			
	Jordan	Deir Alla*	1
South America			
	Colombia	Palmira	1
	Ecuador	Boliche	1
		Portoviejo	1

* Analysis was not conducted by INTSOY

Table 3. Correlation coefficients of agronomic variables from Zones I, IV and VII from the First INTSOY Variety Evaluation Experiment.

	Zone	Yield kg/ha	100 Seed Weight	Days to Maturity	Plant Height cm
Yield	-0.18*				
Seed Weight	-0.34**	0.66**			
Days to Maturity	0.33**	0.28**	0.29**		
Plant Height	0.11	0.16*	-0.08	0.32**	
Month of Planting	-0.35**	-0.22**	-0.07	-0.12	-0.20*

* Significant at the 5% level

** Significant at the 1% level

Table 4. Country and addresses of Distributors of the Second Variety Evaluation Experiments.

Africa

Algeria

Mr. N. Kadra
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19 Rue Khodjet El Djeld
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Project Manager
Senqu River Project
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Mauritius

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Principal Agricultural Officer
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Project Manager
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Sierra Leone

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Somalia

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Table 5. Source and Varieties being Evaluated at the University of Puerto Rico for Testing in Future Variety Evaluation Experiments.

Source	Variety
Australia	Daintree Gilbert Ross
Brazil	Santa Rosa UFV-1
Colombia	ICA-Pance
India	Ankur
Nigeria	M-79 M-90 M-98 M-216 M-281
Rhodesia	Buffalo Oribi Rhosa
United States	Biloxi Otootan
Viet Nam	No. 29

APPENDIX II

Information Sources for TAXIR

Information which is entered into the computerized soybean data bank concerns five sources of soybean germplasm. These include named soybean varieties, type collection lines, species collections, plant introductions, and forage collections. Forage collection varieties, which are no longer produced as such, have all been entered into the data bank from previously published lists. Named varieties are entered as they appear in publications, such as the Crop Science journal, shortly after registration. Much of the agronomic information regarding both new varieties and already established ones is obtained from the Uniform Soybean Test evaluations carried out by the U.S.D.A. Agricultural Research Service in the northern and southern regions of the United States. As new evaluations appear concerning disease resistance or other agronomically useful characteristics of established varieties these are accordingly entered into the data bank. Type collection lines and plant introductions (PI's) are entered from published lists as they are obtained. Information on PI numbers becomes available when experimental stations evaluate large numbers of plant introductions for particular characters. One such example is the Taiwan Agricultural Research Institute, Taipei, which screened 3,000 soybean PI's and named varieties for various agronomic characters, particularly resistance to rust disease. The results were published in booklet form, and have been added to the data bank. Species collections are obtained from lists made up by the U.S. Regional Soybean Laboratory at Urbana, Illinois, where the PI species collection is housed.

In general, information for the data bank comes from a number of different sources, of which a checklist is kept for future reference. Entries already in the TAXIR system are constantly being updated as new evaluations appear, and new entries are added as they become available.

At present (March, 1975), there are 3,693 entries in the TAXIR data bank with a maximum of 157 characters scored for each entry.

APPENDIX III

Soybean Entomology Research

Personnel changes in the Soybean Entomology Research Program were made during the year to increase the ability of INTSOY to become more responsive to major problems in the area of international soybean insect research and to develop insect pest management programs for tropical and subtropical conditions. The basic changes consisted of adding an Entomology-Pest Management position and discontinuing the Entomology Technician position that serviced the Soybean Insect Research Information Center (SIRIC). The new pest management position was filled by Michael E. Irwin who joined INTSOY November 1, 1974. The Soybean Faunal Analyst George L. Godfrey, whose basic responsibilities are to the International Reference Collection of Soybean Arthropods (IRCSA) assumed supervisory responsibilities for coordinating the international dimensions of SIRIC. The two staff members supported by this research contract are members of the 14-member Illinois Soybean Entomology Team. The INTSOY supported members of this team are responsible for giving leadership to the international dimension of the team's work. The principal objectives of the INTSOY entomology program are to devise insect control strategies that encourage economically high yields and to aid international researchers involved in solving soybean-insect problems.

Accomplishments

The insect-pest management specialist, during the few months that he has been with INTSOY, has initiated cooperative research with INTSOY's soybean plant pathologists. Together they initiated experiments in Puerto Rico to determine the speed with which soybean mosaic virus spreads through soybean fields by aphids. Laboratory tests also have been started to find simple and economical methods for isolating potential vectors of soybean viruses. The insect-pest management specialist also has explored the feasibility of adapting, for use in Puerto Rico, the pest management guidelines that are being tested for Illinois soybeans.

Assistance to soybean researchers outside of INTSOY mainly was provided by the International Reference Collection of Soybean Arthropods (IRCSA) and the Soybean Insect Research Information Center (SIRIC). IRCSA has demonstrated the ability to function as a specialized identification center. During FY 75, eight major soybean pest management research programs submitted approximately 3,000 insect specimens for identification. A total of 1,460 specimens representing 358 species was identified. Detailed identification reports and, when requested, pertinent literature were sent to the individual soybean research programs after examining the insect specimens. Those research programs receiving this assistance are associated with the following institutions:

Domestic:

Biological Control of Insects Research Laboratory
USDA/ARS
Columbia, Missouri

Department of Entomology
North Carolina State University
Raleigh, North Carolina

Department of Entomology
Purdue University
West Lafayette, Indiana

International:

FAO/UNDP
Managua, Nicaragua

USAID/EMBRAPA
Porto Alegre, Brasil

Departamento de Zoologia
UFP
Curitiba, Parana, Brasil

Campo Agricola Experimental "Huastecas"
I.N.I.A., S.A.G.
Tampico, Tamaulipas, Mexico

Centro de Investigaciones
Agricolas del Noreste (CIANO)
I.N.I.A., S.A.G.
Ciudad Obregon, Sonora, Mexico

There has been an expansion of the collection's geographical coverage. Most notable is the inclusion of specimens from the Peoples' Republic of China that Dr. Richard Bernard, USDA, secured during his recent trip to that country. Other new areas include Australia, Sudan, Ethiopia, and Nicaragua.

Several important species were added to the collection during FY 75 through the receipt of specimens for identification, the survey of the soybean arthropod fauna in Mexico, the exchange of reference collections of major soybean insects with institutions in Brazil and Australia, and research programs in Illinois. Included are Orosius argentata (Evans), a widely distributed leafhopper which is a known disease vector; Heliothis punctigera (Wallengren), the native budworm of Australia; Zizeeria otis labratus (Godart), a serious defoliator of soybean in Australia; Stomopteryx simplexella (Walker), the soybean moth; three species of Cerotoma, viz., C. dilatipes (Jacoby), C. ruficornis (Olivier), and C. atrofasciata (Jacoby), all of which are potentially harmful; and a newly described tachinid fly, Chaetophlepsis plathypenae (Saborsky), a parasite of the green cloverworm.

There presently are 1,678 identified species represented in IRCSA. This is an increase of approximately 400 species during FY 75. A breakdown of the 1,678 species into ecological categories reveals the following:

Phytophagous species	12%
Opportunistic species	2%
Pollinators	3%
Parasites	8%
Predators	21%
Incidental species	8%
Unknown associations	46%
Total	100%

The Soybean Insect Research Information Center (SIRIC) contains complete copies, abstracts, or titles of 12,500 references on soybean arthropods. New titles are added continually with 2,500 additions during FY 75. This is less than 1/2 the number of additions made during FY 74, reflecting the discontinuance of the position that serviced SIRIC.

A fourth bibliography in the series on the Literature of Arthropods Associated With Soybeans was published in February 1975 through the facilities of SIRIC. The new publication co-authored by a contract staff member, cooperating members of the Department of Entomology, University of Florida, and one INTSOY staff member is "A Bibliography of the Velvet Bean Caterpillar, Anticarsia gemmatalis (Hubner) (Lepidoptera: Noctuidae)."

The publication "Selected Literature of Soybean Entomology," G. L. Godfrey, editor, which was first reported in the FY 74 report has received an enthusiastic response from the scientific community. A second printing of the publication was ordered during FY 75. Requests for copies of this publication have been received from 67 offices and institutions outside the U.S.A.; 25 U.S. universities and state institutions, 9 USDA laboratories and offices and 4 private corporations in the U.S.A. Based on these requests and the initial mailing, copies have been disseminated to 44 nations.

APPENDIX IV

Soybean Pathology Research

Work was formally initiated in soybean pathology research with the addition of two scientists (one FTE). J. B. Sinclair, Professor of Plant Pathology, was assigned on a quarter-time basis and R. M. Goodman, Assistant Professor of Plant Pathology, on a three-quarter-time basis. The remaining portions of their time are with the UIUC College of Agriculture. The assignment of Professor Sinclair to the quarter-time appointment reflected his input to the program since its beginning. This combination of expertise gives coverage to soybean diseases caused by bacteria, fungi and viruses.

The objectives of INTSOY's research in pathology are: (i) to identify the limiting soybean diseases in the tropics and subtropics, (ii) to generate basic information about soybean pathogens that can be used to predict their spread and importance, (iii) to devise methods to control or reduce the impact of diseases, and (iv) to assist in breeding tropically adapted soybean cultivars with resistance to important pathogens. The work is being done in coordination with plant protection specialists, agronomists and the INTSOY plant breeder both on the UIUC campus and the University of Puerto Rico, Mayaguez Campus.

Identifying soybean diseases. Soybeans are historically a crop of the temperate regions, and so our knowledge of soybean diseases is based primarily on experience in temperate latitudes. Therefore, our first important objective is to identify diseases that occur in soybeans in the tropics and subtropics. INTSOY pathologists at the UIUC and UPR, Mayaguez are closely observing soybeans, and other more common tropical legumes, for diseases. INTSOY personnel also cooperate with other pathologists around the world to keep abreast of soybean disease development elsewhere.

This type of information gathering is a continuous activity. Whenever INTSOY pathologists visit a cooperating country, attend an INTSOY regional workshop, read publications from other countries, or talk about soybeans with visitors disease problems are reviewed and discussed and new information is generated. This information becomes part of the increasing expertise of the INTSOY pathologists.

It is impossible to be able to have contact with individual scientists on a personal basis in each of the countries cooperating with the INTSOY Variety Experiment Program. Therefore, in the data collecting sheets sent to each cooperator conducting an INTSOY variety experiment, there is space provided for them to comment on disease problems. During the year the data collection instructions were revised to include a request for descriptions of symptoms of virus diseases rather than simple identification of the fact that a virus might be involved. Few of the cooperators are equipped to accurately diagnose virus diseases, but with these new instructions, it is hoped to obtain more accurate information on the occurrence of virus diseases, along with diseases caused by other agents.

The final selection of cultivars and locations for planting the "disease nurseries" in Puerto Rico was completed near the end of this reporting year. These are now being planted and observations will be made throughout the development of these plants for various diseases. Disease tissues will be collected and the pathogens isolated and identified. Some of this work has been done by the UPR pathologist .

Exchange of scientific information. The INTSOY pathologists, like other INTSOY personnel, attach great importance to their role in promoting exchange of scientific information and in communicating results of their research to other scientists in soybean development programs. They maintain contact through correspondence with soybean scientists in national, university and international soybean programs.

INTSOY pathologists are completing work on three literature summary publications: (i) an international Soybean Disease Compendium, (ii) an Annotated Bibliography on Soybean Diseases; and (iii) a Bibliography of Soybean Virus Literature. The development of the Soybean Disease Compendium has been supported in part by INTSOY, the American Phytopathological Society, and the American Soybean Association. The development of the Annotated Bibliography and the Soybean Virus bibliography have been supported in part by INTSOY and the UIUC College of Agriculture. It is anticipated that these publications will become available during 1975.

Research on soybean diseases. Early results with soybean diseases in the tropics and subtropics indicate several areas that require more detailed research: (i) identification of important soybean viruses; (ii) spread of seedborne soybean viruses; (iii) role of seedborne microorganisms in seed deterioration and death; (iv) interaction of soybean cyst nematode and the charcoal rot fungus on soybeans; (v) soybean rust and its control; and (vi) general control of soybean diseases.

Identification of important soybean viruses in the tropics and subtropics. Very little experience with soybean diseases that occur under tropical conditions has been recorded in the soybean disease literature. Since all but one of the important soybean viruses known in temperate areas are transmitted by insects, and since many insects and legumes other than soybeans that might serve as virus reservoirs are present in tropical areas, an important objective of the early work in soybean virology is to identify the viruses that occur in soybeans grown under tropical conditions. In this reporting period, studies were limited to viruses infecting experimental plantings at two substations of the Estacion Experimental Agricola in Puerto Rico.

Host range and serology studies were used. Specific rabbit antisera prepared at UIUC or obtained from other virologists in the United States were used in microprecipitin and Ouchterlony double diffusion tests. Samples for microprecipitin tests were prepared by a new method developed during the contract year. This method involved use of microbiological filters to clarify the homogenate of tests leaves rather than the usual use of a moderately high speed centrifuge. This development allows field samples to be analysed without the need for an equipped laboratory. The efficacy of the method with field collected tissue samples was checked by conducting serological tests on tissue collected at the Isabela Substation in Puerto Rico. Ouchterlony tests were done by using standard methods.

Samples for analysis were collected in August, 1974, and January, February and March, 1975, at the Isabela and Lajas substations. Tests were conducted either at the University of Puerto Rico, Mayaguez Campus or at UIUC.

Viruses positively identified to date from soybeans in Puerto Rico are soybean mosaic virus, tobacco ringspot virus, cowpea mosaic virus, and Rhynchosia mosaic virus. An especially severe strain of cowpea mosaic virus was first found in experimental plantings of local cultivars of cowpeas at the Isabela Substation. This virus infects soybeans and causes severe symptoms. It was found naturally infecting soybeans at Isabela, P. R., in single infections, and in double infections with tobacco ringspot virus.

Other virus collections from wild legumes in Puerto Rico have been made but the viruses are not yet identified.

Spread of seedborne soybean viruses. The viruses of soybeans are an important concern in a program such as INTSOY, where the objective is to generate new varieties for testing and eventual adaptation in many parts of the world. Meeting this objective requires frequent shipment of soybean seeds from one country to another and from one natural community to another. It is of prime importance that the seed produced by, as well as the seed introduced into, the INTSOY program be free of seedborne viruses.

Soybean mosaic virus and tobacco ringspot virus are known to be seedborne in soybeans. Both are also transmitted by insect vectors. Since the insect vectors can, if present during the early part of the growing season, spread the viruses to healthy plants whose seeds then become infected, it seemed important to begin experiments on the rate and timing of virus spread in the field at locations where the INTSOY breeding program is underway. During the present contract reporting period, a series of experiments was planned and initiated to determine the importance of field spread of soybean mosaic virus by aphid vectors. The first experiment was planted at Isabela, P. R., just before the end of the contract reporting period. These experiments are cooperative studies by the INTSOY virologist and entomologist (UIUC) in cooperation with the INTSOY pathologists and plant breeder in Puerto Rico.

Role of seedborne microorganisms in seed deterioration and death. Research in the area of soybean seed pathology was a departmental and INTSOY concern prior to the formal appointment of Professor Sinclair to the INTSOY program. Studies center on the nature of the microorganisms involved and the mechanisms of seed or embryo death. Results indicate that a bacterium found in the soybean seed coat may contribute to poor stand establishment of soybeans in the tropics.

Many soybean seeds incubated at 35°C in a moist chamber became covered with a bacterial growth. The isolates from such affected seeds reacted identically as the ATCC isolate of *Bacillus subtilis* to seven biochemical tests. This is the first report of *B. subtilis* being seed-borne on surface-sterilized soybean seeds. Streak plates from individual seeds show that *B. subtilis* was not the only bacterium associated with these seeds. Occasionally gram-negative, small, rod-shaped bacteria were encountered. These appeared in very low numbers in comparison to *B. subtilis*. *B. subtilis* was always the most frequently isolated bacterium.

The presence of *B. subtilis* on soybean seeds increased with increase in incubation temperature from 25° to 50°C. The bacterium did not develop on seeds incubated at 15°, 20° and 55°C. These temperatures inhibited growth of the bacterium. Soybean seed germination declined with increased incubation temperature from 20° to 35°C. All seeds with *B. subtilis* were dead and had

begun to decay. Seeds did not germinate at 40°C or above. Germination at 15°C was less than that at 20°C. There was a negative correlation between the decrease in germination and the increase in the occurrence of the bacterium at 25° (r= -0.60) 30° (r= -0.88) and 35°C (r= -0.35).

The occurrence of B. subtilis on seeds increased with each increase in storage time and temperature.

There were no significant differences in the occurrence of the bacterium between the 4- and 6-week incubation and between 40° and 45°C. There was a decrease in the percent germination with increase in storage time and temperature. There were no significant differences in germination between the 4- and 6-week incubation and between 40° and 45°C. There was an inverse correlation (r= 0.873) between the occurrence of the bacterium and decrease in germination at all temperatures and times. The percent occurrence of internally seedborne fungi at 25°C did not vary significantly between the treatments.

When soybean seeds contaminated with bacteria are planted in soils at 35°C, there is a significant reduction in germination. Soybean seeds planted in soils with a high temperature (about 35°C) in Nigeria, Ghana and other tropical countries, had greatly reduced germination. It is suggested that B. subtilis may be an important factor in this situation.

Soybean seeds from the Peoples' Republic of China, Egypt, Ethiopia and Thailand were assayed at 40°C. Colonies of the B. subtilis were recovered from all seed lots and identification was confirmed using biochemical techniques.

Interaction of soybean cyst nematode and the charcoal rot fungus on soybeans. Five-day-old soybean seedlings of the varieties Clark 63 and Custer were inoculated with either Heterodera glycines (soybean cyst nematode) or Macrophomina phaseolina (charcoal rot fungus) alone or in combination. Clark 63 is susceptible and Custer is resistant to the soybean cyst nematode. Charcoal rot symptoms were more severe on Clark 63 seedlings when both pathogens were present then when either pathogen was alone. Sumptoms also developed on Custer seedlings inoculated with both pathogens, but symptom development was less severe than on Clark 63. The nematode may have provided infection courts for entry of the fungus during the early stages of plant growth. Populations of H. glycines on roots of Clark 63 were lower when seedlings were infected by M. phaseolina. Only 10 cysts of H. glycines developed on roots of Custer seedling in any treatment by the end of the experiment, and no eggs appeared in the cysts. M. phaseolina appeared to be the dominant pathogen in the complex, yet the two pathogens seemed to act independently of one another. Formation of sclerotia within the roots was demonstrated at early stages of infection of both cultivars by M. phaseolina.

Soybean rust and its control. Another area of research now under consideration is a cooperative study on soybean rust and its control. It is anticipated that a cooperative research project will be developed by INTSOY with Asian pathologists and other U.S. institutions to study this disease. The project will seek inexpensive means to control this disease until cultivars resistant to the causal fungus can be developed.

Control of soybean diseases. Methods of controlling plant diseases vary depending on the properties of the pathogen involved, the host and the circumstances under which the crop is grown.

Control of virus diseases usually depends upon the plant's resistance to infection or upon control of vectors that spread the virus. In practice, only a few viruses are controlled by controlling the vectors, and so our emphasis is on breeding of virus-resistant cultivars.

Diseases caused by seedborne fungi and bacteria, on the other hand, can be controlled in some cases by application of a biotoxic or antibiotic chemical. Results of studies at UIUC show that fungicides may be useful to control some seedborne fungi. A similar approach is being investigated for the control of the seedborne bacterium mentioned previously. Where appropriate, changes in cultural practices may also be effective in reducing or avoiding disease occurrence.

APPENDIX V

Food Science Literature Review

I. Methods of Cooking Soybeans that are Suitable for Home and Village Use

Soybeans originated in Eastern Asia and were used as food before recorded history. The Buddhist religion has been credited with the increased use of soybeans. It is thought that many of the sophisticated soybean products of the Orient have their creation in Buddhist monasteries (Smith and Circle, 1972). The Orient presently has many soybean food products. Soybean fermented foods include soy sauce, miso and tempeh, all of which are fermented with molds in order to develop characteristic flavors. Unfermented foods include soybean milk and tofu (Smith and Circle, 1972).

Like most raw plant foods, raw soybeans must be cooked before consumption. Cooking results in softening of the tissue and destruction of anti-nutritional factors, e. g., trypsin inhibitor. In addition, soaking and cooking will help leach out flatulence causing factors, and (if properly conducted)will prevent the formation of off-flavors.

Adequate cooking of whole soybeans can be accomplished by steaming or boiling in water for about 20 minutes as indicated by inactivation of trypsin inhibitors and urease. A high initial moisture content in the bean is considered to be the most important factor favoring rapid cooking (Albrecht, et al., 1966). According to Rackis, (1965), trypsin inhibitors in either the full fat or defatted soybean flake may be inactivated by steaming at 100°C for 15 minutes. This treatment also resulted in maximum protein efficiency ratios.

Soybeans are infamous because of a characteristic painty or beany flavor. This flavor makes them unacceptable as human food throughout most of the world. The beany or painty off-flavor is thought to result from the action of lipoxygenase acting upon certain unsaturated fatty acids, (Rackis, et al., 1972). It is now believed that the off-flavor is formed when the soybean tissue has been damaged and there is sufficient moisture present for lipoxygenase to be active (Nelson, et al, 1971).

Home Cooking

Many studies have been carried out on the cooking characteristics of a variety of common peas and beans, e.g., kidney beans, lima beans, great northern beans and navy beans (Snyder, 1936; Dawson, et al., 1952; Greenwood, 1935; and Burr, 1969). However there are relatively few references available on the preparation of cooked soybeans at home. Most of these references simply discuss variations of soaking and boiling in plain water, followed by the addition of spices or sauces in order to disguise the presence of soybeans and soybean flavors.

Mueller, et al., (1974) suggested soaking the beans in 3 volumes of water overnight in the refrigerator. Boiling the beans in water for 2 minutes and then setting them aside for one hour at room temperature was suggested as a faster method. For cooking, she advised removing the loose hulls from the soaked beans, transferring the beans and soak water to a kettle and adding enough water to cover the beans one inch deep. The beans were then simmered for one to three hours. The addition of salt or oil was suggested to reduce foaming. It should be noted that the water used is partly softened water.

Rice, (1973) suggested two methods for cooking soybeans. Either soak the beans overnight in cold water and boil them for 3 hours, or bake the soybeans for 2 hours at 325°F. (163°C.).

In an earlier recipe booklet (Van Duyne, 1950) it was suggested that 1 cup of soybeans should be soaked overnight in 3 cups of water. The beans were then boiled for one hour. Van Duyne also suggested cooking the beans in a pressure cooker at 15 psi for 20 minutes.

Two cookbooks written in India by an Indian Home Economist explored the utilization of soybeans in Indian food. Singh (1970) recommended soaking for 6-8 hours in 4 times as much water as soybeans. The soaking water was discarded and the beans were cooked in fresh water. She also gave instructions for preparation of soy flour, soy milk and soybean curd in the home. Kanthamani (1970) also recommended soaking soybeans for 4-8 hours and her recipes stressed the use of soy flours. She included a method for preparation of soy flours in the home.

Village Scale Processing

Mustakas, et al., (1970) developed a method for making a full-fat flour at the village level. The full-fat flour can be made with simple, manually operated equipment and with minimum cost. The flour was stated to have good acceptance and it was expected to have good nutritive value. The method of preparation is as follows:

Soak beans for 6 hours

|

Immersion cook for 10 minutes

|

Air dry

|

Hand crack in a flour mill

|

Dehull in a manual winnower

|

Hand grind in a flour mill

In a paper on the development of soybean dal, Spata, et al., (1974) showed that the addition of sodium bicarbonate to the cooking water causes substantial tenderization. The most effective method of tenderization reported was to dehull the soybean and boil it in a mixture of soft water and 0.5% sodium bicarbonate.

Wei, et al., (1973) found that, regardless of the soaking procedure, soybeans blanched in bicarbonate solution were more tender than beans blanched in tap water. It was concluded that soaking for 5 hours followed by blanching in 0.5% sodium bicarbonate solution was highly effective for tenderizing soybeans.

During the development of a drum dried soy:banana weaning food, Bird (1970) noted that the use of sodium bicarbonate for soaking and blanching resulted in a darker colored dry and rehydrated product (Bird, et al., 1975). Apparently soybeans soaked and blanched in sodium bicarbonate develop a darker color. This effect has been noted by others (Van Duyne, personal communication).

Use of sodium bicarbonate for blanching aids in the removal of oligosaccharides which apparently cause flatulence. For maximum removal of oligosaccharides, Ku (1970) recommended cooking the beans for 5 minutes and then soaking for 30 minutes in 0.5% sodium bicarbonate solution. This treatment was followed by dehulling the beans and holding in water at 85°C for 40 minutes. This method removed approximately 80 percent of the oligosaccharides but also increased the nitrogen (protein) lost from about 5% to 10%, compared to conventional soaking and boiling in tap water.

Badenhop et al.,(1973) investigated the use of a solution of sodium hydroxide as a pre-treatment for preparation of soybean beverage. He found that alkaline conditions render the trypsin inhibitor more labile to heat. The only amino acid which seemed to be affected by a high pH was cystine. He recommended soaking the beans in 5 volumes of 0.05% NaOH at 50°C. The extent of destruction of cystine, was not serious if the pH was below 8. Badenhop supplemented the soy beverage with methionine to correct for cystine loss due to alkaline soaking.

Earlier, Rambaud, (1965) patented a method for improving the food quality and ease of use of cooked soybeans. He suggested treating soybeans for 20 minutes at 80°C. with a mixture of lime and ammonia (NH_3). The highly alkaline solution was claimed to result in rapid destruction of trypsin inhibitors and other undesirable anti-nutritional factors. After soaking, the beans or bean flour was dried. During drying, the ammonia was removed and the pH of the flour or beans returned to approximately neutral.

II. Important Abstracts on Soy Flours

Hayward, J. W. and G. M. Diser. Soy Protein as Soy Flour and Grits - for Improving Dietary Standards in Many Parts of the World. Soy Digest, 21(10): 14, 1961.

This article is devoted primarily to various pertinent aspects of soy flour and grits, as worthy food ingredients for use in diets, both at home and abroad, as a source of inexpensive high quality protein to supplement the cereal portion of many foods. The most important subjects covered herein, with respect to soy flour and grist, are: (1) historical background; (2) definitions; (3) types and/or kinds; (4) processing; (5) composition; (6) content of most important amino acids in soy flour and grits, in a few other vegetable-type proteins and in the cereal grains--corn, wheat and rice; (7) nutritive properties of soy flour and grits; (8) recommended uses in conventional and special diets; (9) economic aspects; and (10) soybean milk and/or soy milk for infants and children.

As a result of their increasing availability on a worldwide basis, soya products serve very effectively to supplement the diets of people in those areas where milk and other animal proteins are either economically unavailable or in short supply. Properly processed soy flour and grits furnish protein that is comparable or very nearly equal in nutritive value to milk and meat. These products from the soybean serve as a source of this excellent quality protein at a fraction of the cost of the protein from animal sources. In addition, and of greater importance, is the fact that the protein from soy flour and grits can

supplement the poor quality protein in cereals to the extent that the nutritional value of the cereal-and-soya mixture is comparable to that of protein from animal sources.

Mustakas, G. C., W. J. Albrecht, G. N. Bookwalter, J. E. McGhee, W. F. Kwolek and E. L. Griffin, Jr. Extruder-Processing to Improve Nutritional Quality, Flavor, and Keeping Quality of Full-Fat Soy Flour. Food Technology, 24:102-108, 1970.

Extrusion-cooking, a recent process development for cooking soybeans, holds promise for converting them to a high-quality food product. The short cooking time in an extruder minimizes damage to nutritional properties but still adequately removes growth inhibitors. However, the quality of the final product depends on the process conditions used. A series of 24 extrusion-cooking experiments was carried out under various combinations of time, temperature, and moisture content to determine optimum cooking conditions in the preparation of high-quality soy flour.

Flour of high nutritive value, flavor, and good stability was prepared by dehulling and preheating unextracted soybean meats to inactivate lipoxidase, premixing with water to add moisture, extruding, cooling, drying, and grinding. Product tests showed that heat-labile nutritional factors, such as thiamine and available lysine, were maintained during processing. Inactivation of growth inhibitors was indicated by the low urease activity, trypsin inhibitor (TI), and nitrogen solubility index of the product.

Protein efficiency ratios (PER) established in 4-week rat feeding tests confirmed chemical results. PER values progressively improved up to 89% inactivation of TI. A method was developed for optimizing the extruder process variables to give good nutritive value, flavor score, and oxidative stability.

Albrecht, W. J., G. C. Mustakas, J. E. McGhee and E. L. Griffin, Jr. A Simple Method for Making Full-Fat Soy Flour. Cereal Science Today, 12(3):81-83, 1967.

A simple procedure is reported that gives soy flours which have good taste acceptance and should have good nutritive value. All the equipment is capable of manual operation and nominal in cost. The heat requirement is only that needed to boil the cooking water. Adapting the process to a developing country should not be difficult. However, environmental conditions could necessitate some alterations to the procedure; for example, drying the cooked soybeans in an area of very high humidity might require selection of the season or a modified drying method. The processing steps are whole soybeans - water soaking - boiling - air drying - hand cracking - dehulling - hand grinding - full fat soy flour.

Mustakas, G. C., W. J. Albrecht, J. E. McGhee, L. T. Black, G. N. Bookwalter and E. L. Griffin, Jr. Lipoxidase Deactivation to Improve Stability, Odor and Flavor of Full-Fat Soy Flours. Journal of American Oil Chemist's Society, 46:623, 1969.

Oxidation of soybean lipids catalyzed by lipoxidase was prevented by heat treatment of soybean meats, which were then ground to give a full-fat soy flour free of rancid odor and flavors. Previous studies showed that lipids in cracked, dehulled, soybeans rapidly oxidized after the lipoxidase system was activated by increasing moisture content to 20%. A series of experiments are reported in which various heat treatments were evaluated for effectiveness of lipoxidase deactivation. Dry heat to 212°F, steaming, or both, deactivated lipoxidase to give flours that had low values of peroxide, conjugated diene and

free fatty acid and had good flavors after 2 years' storage. Wet heat alone was also an effective treatment, whereas wet heat preceded by dry heat at 180°F gave poor flavor stability after 2 years. Gas liquid chromatography studies gave evidence that the rapid formation of volatiles in full-fat soy flours was catalyzed by an enzyme system. A 10 member taste panel was able to detect significant flavor and odor differences between oxidized and nonoxidized samples.

Anderson, R. A., V. F. Pfeifer, G. N. Bookwalter and E. L. Griffin, Jr. Instant CSM Food Blends for World-Wide Feeding. Cereal Science Today, 16(1):5-11, 1971.

In summary, the characteristics of instant CSM-type blends reflect the characteristics of the corn component. Further, the characteristics of the blends can be tailor-made to some degree by the method and amount of cooking of the cereal component, by operating conditions used in cooking, and by grinding conditions and particle size distribution of the cereal portion. These variables permit control of flavor and texture, as well as properties of the mix in use.

The instant CSM-type food blends described are completely precooked and ready for immediate consumption of merely mixing with water and allowing to stand for a few minutes. The resultant blends serve as palatable, acceptable, and nutritious foods offering great potential in world feeding.

Harper, J. M. and K. Lorenz. Production of a Full-Fat Soy Flour Using an Agitated Granular-Bed Roaster. Preprint.

This study has shown that a high quality inexpensive full-fat soy flour can be produced in a high temperature salt bed roaster. The soybeans are fed down the center of a perforated helix in an inclined rotating drum. At the back of the drum it falls into a bed of salt heated to 300°-325°F and is intimately mixed with the salt. The product is conveyed forward by the helix but the salt falls back through the perforations in the helix. Residence time is about 10-30 seconds and is controlled by adjusting the speed of rotation of the drum. A holding tube, which follows the roaster, allows sufficient time for the added heat to completely penetrate the bean and inactivate the lipoxygenase and anti-nutritional factors. After cooling the soybeans are coarsely ground by a set of break rolls, and dehulled. The soybean pieces are ground to a flour in a hammer mill.

Dutra de Oliveira, J. E. Nelson de Souza. Metabolic Studies with a Corn and Soya Mixture for Infant Feeding. Archivos Latinoamericanos de Nutricion XVII (No.3) 197-206, 1967.

Nitrogen balance was used to study, in normal and malnourished children, the nutritive value of a vegetable protein mixture. Basically the mixture contained corn and soybean flour. The results were compared with those obtained with children fed cow's milk.

It was found that, when the undernourished children received this mixture as the only source of food, absorption and retention of nitrogen were 70.1 and 21.3% respectively. These values were inferior to those obtained with children fed cow's milk.

In the group of normal children this vegetable mixture increased the absorption and retention of nitrogen when substituted for part of their basic diet. This absorption and retention showed to be equal and even greater than when cow's milk substituted part of the basic diet. This is a very important finding considering that this mixture is intended as a supplement to the regional diets of low nutritive value.

Graham, George G. and Juan M. Baertl. Nutritional Effectiveness of Soy Cereal Foods in Undernourished Infants. Journal of American Oil Chemists; Society, 51:152, 1974.

These studies show that a variety of cereal-soy foods can be the major or only source of protein in the diet of growing infants and children. These included various combinations of cornmeal and soy flour, with and without added dry skim milk or methionine; a wheat flour-wheat concentrate mixture or whole wheat flour with soy flour; oat and soy flours; and a corn-wheat-soy flour macaroni. Apparent absorption of nitrogen from each of these mixtures was similar, averaging 76.3 $\pm$ 0.6 (SEM)% of intake, but inferior to that from casein in the same children, which averaged 86.8 $\pm$ 0.4% of intake. Apparent retentions of nitrogen averaged 26.6 $\pm$ 0.8 and 33.8 $\pm$ 1.0%.of intake respectively, with all but one of the soy-cereal combinations being similar. This one had a mean retention equal to that from casein, possibly as the result of "instantizing" of the cornmeal which probably resulted in increased availability of dietary energy. For all the mixtures, nitrogen retention was influenced by the efficiency of nitrogen absorption, suggesting that processing methods can improve the nutritional quality of these foods.

Fomon, Samuel J. Nitrogen Balance Studies with Normal Infants Fed Soya Bean Protein. Conference on Soybean Products for Protein in human food, USDA-ARS, p. 175-178, 1961.

Nitrogen balance studies reported from the Metabolic Unit of the State University of Iowa during the past few years have included investigations with normal full-term infants receiving approximately 7 percent of the calories as protein from human milk (1, 2), cow milk (3), or soya bean (4), A review of results with soya bean protein is presented here and interpreted in the perspective provided by the other studies. The proteins of human milk, cow milk, and soya bean were found to have similar abilities to promote retention of nitrogen.

Mizrahi, Sylvia, Gideon Zimmermann, Zeki Berk and Uri Cogan. The Use of Isolated Soybean Proteins in Bread. Cereal Chemists, 44:193, 1967.

The effect of including isolated soybean proteins (isoelectric and Ca-coagulated) in wheat bread on its baking characteristics, acceptance and nutritive value has been investigated. Admixture of soybean proteins was found to increase the water-absorption capacity of the flour. Loaf volume decreased proportionately with the level of protein addition. However, when 1% lecithin was included in mixes containing less than 6% soybean protein, the decrease in loaf volume could be counteracted. Isolated protein at levels up to 8% did not affect the taste significantly. The nutritive value of the bread samples, measured as protein efficiency ration(PER), increased with the percentage of soybean protein. The increase in PER was in linear relationship with the lysine content of the bread. It is concluded that isolated soybean protein may be admixed with wheat flour up to the level of 6% as a means of successful nutritional supplementation without significant impairment of over-all acceptability.

Tsen, C. C., E. M. Peters, T. Schaffer and W. J. Hoover. High Protein Cookies I. Effect of Soy Fortification and Surfactants. Bakers Digest, 47(4):34, 1973.

Wheat flour fortified with soy flour and protein isolates containing 24% soy flour or soy protein isolates resulted in 60-100% raise in protein content and balances their amino acids but drastically reduces cookie width

(spread) and increases thickness (height). Both effects are enhanced progressively as fortification increases. Adding nonfat dry milk reduces spread with or without soy fortification. Soy products can be profitably used to substitute for nonfat dry milk. Sodium stearoyl-2-lactylate (SSL) and sodium stearyl fumarate (SSF) and sucrose esters increase spread and reduce shortening requirement. Use of these 3 ingredients in regular and high-protein cookies will improve quality reduce calorie content and lower product cost.

Sipos, E. F., E. Turro and L. D. Williams. Soy Protein Products for Baked Foods, Baker's Digest, p. 29, 1974.

The authors feel that there is a broad market for soy protein products in new food items, as well as in the improvement of more conventional processed food lines. For this reason, a better understanding of their functional qualities and of the means for modifying such qualities are of prime importance.

The optimistic outlook for the long-term future is also rooted in the conviction that the protein of the soybean will assume an important place in providing for man's increasing need for a nourishing and appealing food.

This article reviews the production of defatted soy flour, concentrate and isolate. The nutritive value of the protein is discussed. A brief review of many applications in baked foods is given.

III. Important Abstracts on Soy Beverages

Monahan, Louis J. and Charles J. Pope. Process of Making Soy-Milk. US Patent #1,165,199, December 21, 1951.

The invention relates to a new process of producing soy milk and its products. After soybeans are reduced to a powder, the powder is rendered into an emulsion with lime water or sodium bicarbonate in order to partially counteract the taste and the oily odor therefrom. The claims included: the process of making soy milk which consists of producing an emulsion with water by working the beans with water...until...thoroughly emulsified, straining off the liquid and adding more water to the beans, further agitating the mass to recover approximately all of the milky constituents therefrom and cooking or boiling the recovered liquid for an extended period of time.

Thevenot, Gaston D., (1) Process of Manufacturing Milk and Cream Substitutes. US Patent #1,359,633, November 23, 1920; (2) Process of Making Vegetable Milk. US Patent #1,444,812, February 13, 1923; (3) Process of Making Vegetable Milk. US Patent #1,541,006, June 9, 1925.

The invention relates to improvements in processes of manufacturing milk and cream substitutes, and is based upon the discovery that such substitutes may be manufactured from...soya beans; that the objectionable flavors and coloring matter may be removed, and a finished product obtained which possesses the appearance and taste of cow's milk, as well as its nourishing properties. The process involves soaking, grinding, extraction in slightly alkaline solution. The solids are allowed to settle out and the liquid portion is emulsified. In order to improve the taste, the liquid is heated to about 70 C. Extraction with alcohol to improve the flavor of the beverage and spray drying the beverage are claimed as part to the last two patents.

Miller, Harry W. Process of Making Vegetable Milk. US Patent #2,078,962, May 4, 1937.

This invention relates to a process of making vegetable milk, and it is the objective of the invention to provide a method of this kind especially for the production of vegetable milk from the soya bean, the various steps being physical. The claims include, "A process of preparing vegetable milk from the soya beans comprising the steps of soaking whole beans, grinding the soaked beans to a pulp to expose the cellular structure of the beans and adding water during the grinding operation, separating the liquid from the pulp, heating the liquid to the boiling point, adding sufficient elements such as sugar, vegetable fats and salts, agitating the mixture during the cooking operation... and then passing the fluid through a homogenizer."

Smith, A. K. and A. C. Beckel. Soy or Vegetable Milk. Soybean Digest, 6:18-23, 1946.

This article contains an extensive bibliography on the preparation of soybean milk using cold and hot extraction procedures.

Van Buren, J. P., K. H. Steinkraus, L. R. Hackler, I. El Rawi, and D. B. Hand. Heat Effects on Soymilk: Indices of Protein Quality in Dried Soymilks. Journal of Agricultural and Food Chemistry, 52:524-528, 1964.

Soymilk powders were prepared by various heating and drying procedures. Adequacy of heat treatment was evaluated by means of an assay for trypsin inhibitor. Soluble nitrogen and urease activity levels could not substitute for the extent of trypsin inhibitor destruction as an indicator of adequate heating. Overheating was accompanied by a decrease in available lysine and an increase in darkness of the product. Variations in free amino group levels depended on the conditions of heat treatment. Soluble nitrogen had no correlation to heat damage. Regression equations relating indices of protein damage to biological value are presented.

Hackler, L. R., J. P. Van Buren, K. H. Steinkraus, I. El Rawi, and D. B. Hand. Effect of Heat Treatment on Nutritive Value of Soymilk Protein Fed to Weanling Rats. Journal of Food Science, 30(4):723, 1965.

Cooking soymilk 1 to 6 hours at 93 C had no adverse effect on protein efficiency, growth, or available lysine. 32 minutes at 121 C resulted in a definite decline in PER and an indication that available lysine was declining (greater drop after 40 minutes). PER was dependent on time and temperature of heat treatment. For spray-drying, an inlet temperature of 277C or higher resulted in a drop in PER, with concurrent drop in lysine. Drying (spray, vacuum roller, atmospheric roller and freeze) resulted in no significant change in nutritional quality; freeze-drying resulted in a slightly lower growth rate and PER value.

Hackler, L. R., and B. R. Stillings. Amino Acid Composition of Heat-Processed Soymilk and its Correlation with Nutritive Value. Cereal Chemists, 44(1):70, 1967.

Heating for as long as 4 hours at 93 C resulted in no significant changes in amino acid composition. Decreases in some amino acids (especially cystine) were found at 121 C. Spray-drying inlet temperature is critical.

The amino acids destroyed were different from those when soymilk heated at 121 C. Therefore heat-processing conditioners must be carefully controlled to obtain soymilk of highest nutritional quality.

Hand, D. B., K. H. Steinkraus, J. P. Van Buren, L. R. Hackler, I. El Rawi and H. R. Pallesen. Pilot-Plant Studies on Soymilk. Food Technology, pp. 139-142, 1964.

Dry soymilk of superior quality can be made directly from whole soybeans without including a water-extraction step. The yield is higher, and labor costs are reduced. In the direct manufacture of dry milk from whole soybeans a homogenizer is added to the processing line, but an evaporator and filter press are eliminated.

Hafner, Fred H. No More Milk! Soybean Digest, 25(8):22-25, 1965.

Soy beverage powder is a dry blend of the following ingredients: toasted soy flour, sugar, milk powder, wheat starch, calcium di phosphate, stabilizer-flavor blend and vitamin-mineral premix. It has the following composition: protein-35%, fat-1%, carbohydrates-50%, minerals-5%, calcium-.6%, phosphorus-.7%, vitamin A-375 IU/oz, vitamin C-12.5 mg/oz, vitamin B_{12}-.5 mcg/oz, iodine-.025 mg/oz, vitamin D-125 IU/oz. When made according to instructions it yields a beverage which compares favorably with reconstituted nonfat milk powder with the added advantage of having a high content of vitamin A. A deficiency of vitamin A in the diet can result in nutritional blindness (xerophthalmia).

Soy beverage powder is available commercially and can be supplied in limited quantities now but in almost unlimited quantities within a year, costs no more than nonfat milk powder and can be flavored to suit the taste preference of the recipient country.

Wilkens, W. F., L. R. Mattick and D. B. Hand. Effect of Processing Method on Oxidative Off-Flavors of Soybean Milk. Food Technology, 21:86-89, 1967.

A high temperature, rapid hydration, grinding process for dehulled soybeans inactivated the lipoxidase system, the primary off-flavor potentiator and produced a nearly bland soymilk. Gas chromatography was utilized for profile comparison analysis to determine the effect of processing method on flavor development. An acceptable bland milk was produced by grinding unsoaked, dehulled soybeans with water at temperatures between 80 and 100 C and maintaining the temperature for 10 minutes to completely inactivate the lipoxidase enzyme.

Lower temperatures in the range of 60 - 80 C can be used, if sufficient antioxidants are added to the water. The maximum yield of soymilk solids is obtained when the extraction temperature is 60 C. The contribution of nonenzymic fat oxidation to off-flavor under these conditions was insignificant.

Badenhop, A. F. and L. R. Hackler. Effects of Soaking Soybeans in Sodium Hydroxide Solution as Pretreatment for Soy Milk Production. Cereal Science Today, 15(3):84-88, 1970.

Soaking soybeans in a sodium hydroxide solution of approximately 0.05N is a desirable pretreatment prior to a high-temperature grinding operation for the production of soy milk. This procedure produced soy milk of pH 7.37 which was judged by a panel of 14 members to have a significantly better flavor than a water-soak control treatment at the 1% level of significance.

Alkaline conditions were found to render trypsin inhibitor more heat-labile and therefore easier to destroy during heat-processing. Alkaline soaking conditions were also found to increase the niacin content of the soy milk slightly.

A disadvantage of alkaline treatment of soybeans prior to soy milk production appears to be partial destruction of the amino acid cystine, which is reflected in low PER values obtained for the processed soy milk samples of higher pH. The extent of this problem is apparently not very serious except in soy milk of pH 8.0 and higher. Since the beneficial effects of alkaline soaking treatments on the flavor of soy milk occur below pH 8.0, the use of an alkaline soaking treatment as a means of producing a more palatable soy milk would seem to pose no serious nutritional problem.

Fukushima, Danji and Jerome P. Van Burne. Effect of Physical and Chemical Processing Factors on the Redispersibility of Dried Soy Milk Proteins. American Association of Cereal Chemists, Inc., 47:571-578, 1970.

Heating conditions before drying of soy milk (XM) had a large effect on the redispersibility of SM proteins after drying. Redispersibility decreased rapidly to a minimum at several minutes of heating at either 100 or 120 C and then increased gradually at 100 and rapidly at 120 C. Higher pH or lower concentration of SM during heating increased the redispersibility after drying. The redispersibility was also greatly increased by decreasing the concentration of the heated SM, from which the SM was dried. The use of emulsifiers or EDTA had a slight effect on protein redispersibility. However, more effective reagents were disulfide bond-splitting reagents, such as Na_2SO_3, cysteine, 2-mercaptoethanol, and H_2O_2. The reducing reagents showed similar patterns in their relations between the added concentration and the redispersibility. For cysteine, e.g., there was a fairly large and sharp increase in redispersibility at 0.001M; then it dropped abruptly, later rising again to a maximum at 0.050M. The combined effect of cysteine and emulsifiers was additive, but the effect of cysteine was decreased by the addition of EDTA. It is concluded that the disulfide bonds played an important role in the insolubilization of SM protein during the drying.

Mustakas, G. C., W. J. Albrecht, G. N. Bookwalter, V. E. Sohns and E. L. Griffin, Jr. New Process for Low-Cost, High Protein Beverage Base. Food Technology, 25:534-540, 1971.

A method is described for the preparation of full-fat soy flour by extrusion and the subsequent preparation of a soy beverage base by colloid milling, homogenization and spray drying. Estimated cost of the reconstituted beverage was $0.10/lb at the factory.

Badenhop, A. F. and L. R. Hackler. Methionine Supplementation of Soy Milk to Correct Cystine Loss Resulting from an Alkaline Soaking Procedure, Journal of Food Science, 38:471-473, 1973.

In conclusion, it would appear that methionine supplementation is an effective means of improving the nutritive value of alkali-treated, heat-processed soy milk. Methionine supplementation also improved the nutritive value of raw soy milk. In no case, however, did supplementation of the raw

milk make it equal in nutritive value to the supplemented, heat-processed soy milk. This indicates that methionine supplementation alone is not sufficient and that in order to obtain the most nutritious product both heat processing to destroy trypsin inhibitor and supplementation to correct cystine deficiency are required.

Mustakas, Gus C. Process for Obtaining Full-Fat Oilseed-Protein Beverages. US Patent #3,809,771, May 7, 1974.

A full fat oilseed beverage is prepared by suspending full-fat oilseed flour in water, inactivating the lipoxygenase, precipitating the lipid-protein, resuspending the precipitate in water of pH of about 9, heating and cooling the suspension, adjusting the pH to about 7 and clarifying.

Mustakas, G. C. A New Soy Lipid-Protein Concentrate for Beverages. Cereal Science Today, 19:62-73, 1974.

A lipid-protein concentrate (LPC) has been isolated in 94% protein yield by a simple direct process from soybeans. In the procedure, LPC was isolated from full-fat soy flour by isoelectric acid wash at pH 3.5. An acid cook was introduced to inactivate lipoxygenase so that lipid oxidation would not occur and thereby develop off-flavors. Soluble carbohydrates and other water-soluble constituents were removed in a whey fraction during centrifugation. After redispersion in water, the LPC was cooked for 1 minute at pH 9.0 to completely inactivate growth inhibitors and improve the nutritional quality of the protein. Wet-milling in a colloid mill and homogenizing reduced the LPC to a fine particle size and gave a product with excellent suspension properties in water. The resuspended concentrate yielded a drink that was very bland, had smooth mouth-feel, was low in viscosity, and had other desirable beverage characteristics. With the addition of other nutrients such as fat, minerals, vitamins and synthetic flavors, a great variety of high quality beverages are possible. The liquid product can be spray-dried to a reconstitutable powder, if desired, for convenience and for reduced shipping costs.

BIBLIOGRAPHY

Albrecht, W. J., Mustakas, G. C., McGhee, J. E. and Griffin, E. L., 1967. A simple method for making full-fat soy flour. Cereal Science. 12:81.

Albrecht, W. J., Mustakas, G. C. and McGhee, J. E., 1966. Rate immersion studies on atmospheric steaming and immersion cooking of soybeans. Cereal Chem., 43:100.

Anderson, R. A., Pfeifer, V. F., Bookwalter, G. N. and Griffin, E. L., Jr. 1971. Instant CSM Food Blends for World-Wide Feeding. Cereal Science Today, 16 (1): 5-11.

Badenhop, A. F. and Hackler, L. R., 1973. Effects of soaking soybeans in sodium hydroxide as pretreatment for soy milk production. 1970. Cereal Science Today. 15:84.

Badenhop, A. F. and Hackler, L. R. 1973. Methionine supplementation of soy milk to correct cystine loss resulting from an alkaline soaking procedure. Food Science, 38:471-473.

Baker, E. C. and Mustakas, G. C. 1973. Heat inactivation of trypsin inhibitor and urease in soybeans: effect of acid and base additives. Amer. Oil Chemists Society. 50 (5):137.

Bentley, O. G. 1967. Soybean production in the world-limitation and potentials. In "Proceedings of International Conference on Soybean Protein Foods." U.S.D.A. - A.R.S. 71-35. United States Department of Agriculture, Agriculture Research Service, Northern Utilization Research and Development Division, Peoria, Ill.

Bird, D. 1970. Development of a dehydrated soybean banana weaning food. M. S. thesis. University of Illinois, Urbana-Champaign.

Bird, D., Wei, L. S., Ferrier, L. K. and Nelson, A. I. 1975. Weaning food prepared from whole soybeans and bananas by drum drying. Archivos Latinoamericanos de Nutricion. In Press.

Burr, H. K., Kon, S., Morris, H. J. 1968. Cooking rates of dry beans as influenced by moisture content and temperature and time of storage. Food Technology, 22:336.

Calloway, D. H., Colaseto, D. J. and Mathews, R. D. 1966. Gases produced by human intestinal microflora. Nature. 212:1238.

Cristofaro, E., Motlu, F. and Wuhrman, J. J. 1970. Study of effect of stachyose and raffinose on the flatulence activity of soy milks. 3rd Congress of Food Science and Technology. Washington D. C. August.

Dawson, E. H., Lamb, J. C., Toepher, E. W. and Warren, H. W. 1952. Development of rapid methods of soaking and cooking dry beans. U. S. D. A. Technological Bulletin #1051.

De, S. S., Russel, J. S. and Andre, L. M. 1967. Soybean acceptability and consumer adaptability in relation to food habit in different parts of the world. In, "Proceedings of International Conference on Soybean Protein Foods." U.S.D.A. - A.R.S. 71-75. United States Department of Agriculture, Agriculture Research Service, Northern Utilization Research and Development Division, Peoria, Illinois.

DeGroot, A. P. and Slump, P. 1969. The effect of severe alkali treatment on protein. J. Nutr. 98:45.

Dutra de Oliveira, J. E., e. Nelson de Souza. 1967. Metabolic studies with a corn and soya mixture for infant feeding. Archivos Latinoamericanos de Nutricion XVII (No.3) 197-206.

Fomon, Samuel J. 1961. "Nitrogen Balance Studies with Normal Infants Fed Soya Bean Protein". Conference on soybean products for protein in human food, U. S. D. A. - A. R. S. p. 175-178.

Fukushima, Danji and Van Buren, J. P. 1970. Effect of Physical and Chemical Processing Factors on the Redispersibility of Dried Soy Milk Proteins. American Association of Cereal Chemists, Inc., 47:571-578.

Graham, George G. and Baertl, Juan M. 1974. Nutritional Effectiveness of Soy Cereal Foods in Undernourished Infants. Journal of American Oil Chemists' Society, 51:152.

Greenwood, N. L. 1935. Pinto beans: their preparation and palatability. Agriculture Experimental Station of the New Mexico College of Agriculture and Mechanical Arts. Bulletin #230.

Hackler, L. R., Van Buren, J. P., Steinkraus, K. H., El Rawi, I. and Hand, D. B. 1965. Effect of Heat Treatment on Nutritive Value of Soy Milk Protein Fed to Weanling Rats. Journal of Food Science, 30 (4): 723.

Hackler, L. R. and Stillings, B. R. 1967. Amino Acid Composition of Heat-Processed Soy Milk and its Correlation with Nutritive Value. Cereal Chemists, 44 (1):70.

Hafner, Fred H. 1965. No More Milk! Soybean Digest, 25 (8):22-25.

Hand, D. B., Steinkraus, K. H., Van Buren, J. P., Hackler, L. R., El Rawi, I. and Pallesen, H. R. 1964. Pilot-Plant Studies on Soy Milk. Food Technology, pp. 139-142.

Harper, J. M. and Lorenz, K. Production of a Full-Fat Soy Flour Using an Agitated Granular-Bed Roaster. Preprint.

Hayward, J. W. and Diser, G. M. 1961. Soy Protein as Soy Flour and Grits - for Improving Dietary Standards in Many Parts of the World. Soy Digest, 21 (10):14.

Kanthamani, S. 1970. "Tasty Recipes from Soybean." The Directorate of Extension and the USAID. Jabalpur, India.

Ku, S. 1972. Extraction of oligosaccharides in processing whole soybeans. Ph.D. thesis. University of Illinois, Urbana, Illinois.

Leverton, R. M. 1962. Soybean protein in mixed foods. In "Proceedings of International Conference on Soybean Protein Foods." U.S.D.A.-A.R.S. 71-35. United States Department of Agriculture, Agriculture Research Service, Northern Utilization Research and Development Division, Peoria, Illinois.

Mattick, L. R. and Hand, D. B. 1969. Identification of volatile component in soybeans that contributes to the raw bean flavor. Agri. Chem. 17 (1):15.

Miller, Harry W. May 4, 1937. Process of Making Vegetable Milk. US Patent #2,078,962.

Mizrahi, Sylvia; Zimmermann, Gideon; Berk, Zeki and Cogan, Uri. 1967. The Use of Isolated Soybean Proteins in Bread. Cereal Chemists, 44:193.

Monahan, Louis J. and Pope, Charles J. December 21, 1915. Process of Making Soy Milk, US Patent #1,165,199.

Mueller, D. C., Klein, B. P. and Van Duyne, F. O. 1974. Cooking with soybeans. University of Illinois, School of Human Resources and Family Studies, College of Agriculture. Cooperative Extension Service Circular 1092.

Mustakas, Gus C. May 7, 1974. Process for Obtaining Full-Fat Oilseed-Protein Beverages. US Patent #3,809,771.

Mustakas, G. C. 1974. A New Soy Lipid-Protein Concentrate for Beverages. Cereal Science Today, 19:62-73.

Mustakas, G. C., Albrecht, W. J., Bookwalter, G. N., Sohns, V. E. and Griffin, E. L. 1971. New Process for Low-Cost, High-Protein Beverage Base. Food Technology, 25:534-540.

Mustakas, G. C., Albrecht, W. J., McGhee, J. E., Black, L. T., Bookwalter, G. N. and Griffin, E. L. 1969. Lipoxidase deactivation to improve stability, odor and flavor of full-fat soy flours. Amer. Oil Chem. Society, 46:623.

Mustakas, G. C., Albrecht, W. J., Bookwalter, G. N., McGhee, J. E., Kwolek, W. F. and Griffin, Jr., E. L. 1970. Extruder-Processing to Improve Nutritional Quality, Flavor, and Keeping Quality of Full-Fat Soy Flour. Food Technology, 24:102-108.

National Academy of Sciences. 1968. "Recommended Dietary Allowances." 7th ed. Publication 1694, National Academy of Sciences. Washington, D. C.

Nelson, A. I., Steinberg, M. P. and Wei, L. S. 1971. Food Products from Whole Soybeans. Soybean Digest, January.

Nelson, A. I., Steinberg, M. P. and Wei, L. S. 1974. Soy Beverage Base. Patent granted in France and Belgium. Patent pending in other countries.

Pike, L. R. and Brown, M. L. 1967. "Nutrition: An Integrated Approach." John Wiley and Sons, New York, New York.

Rackis, J. J. 1972. Biologically active components. "Soybeans: Chemistry and Technology." ed. by Smith, A. K. and Circle, S. J. Avi Publishing Co., Westport, Connecticut.

Rambaud, M. 1965. Method of Cooking of Soya. November 30, 1965. U. S. Patent #3,220,851.

Rice, W. 1973. The treasure beneath the surface of the fair skinned soybean. May 10. The Washington Post.

Saio, K., Arai, K and Watanabi, T. 1973. Fine structure of soybean seedcoat and its changes on cooking. Cereal Science Today. 18:7.

Sessa, D. J., Honig, D. H. and Rackis, J. J. 1966. Isolation and characterization of flavor and flatulence factors in soybean meal. In "Proceedings of International Conference on Soybean Protein Foods." U.S.D.A. - A.R.S. 71-35. United States Department of Agriculture, Agriculture Research Service, Northern Utilization Research and Development Division, Peoria, Illinois.

Singh, R. 1970. "Soyahar". G. B. Pant University of Agriculture and Technology, India.

Sipos, E. F., Turro, E. and Williams, L. D. 1974. Soy Protein Products for Baked Foods. Baker's Digest, p. 29.

Smith, A. K. and Beckel, A. C. 1946. Soy or Vegetable Milk, Soybean Digest, 6:18-23.

Smith, A. K. and Circle, J. J. 1972. "Soybeans: Chemistry and Technology." Avi Publishing Co., Westport, Connecticut.

Snyder, E. B. 1936. Some factors affecting the cooking quality of the pea and great northern types of dry bean. University of Nebraska, Experimental Station. Research Bulletin #85.

Spata, J. A. and Nelson, A. I. 1974. Developing a soybean dal for India and other countries. World Crops. March/April.

Steggerda, F. R., Richards, E. A. and Rackis, J. J. 1966. Effects of various soybean products on flatulence in adult man. Proc. Society of Exper. Biol. Med. 121:1235.

Thevenot, Gaston D. (1) Process of Manufacturing Milk and Cream Substitutes. U.S. Patent #1,359,633, November 23, 1920, (2) Process of Making Vegetable Milk, U.S. Patent #1,444,812, February 13, 1923, (3) Process of Making Vegetable Milk, U.S. Patent #1,541,006, June 9, 1925.

Tsen, C. C., Peters, E. M., Schaffer, T. and Hoover, W. J. 1973. High-Protein Cookies I. Effect of Soy Fortification and Surfactants. Bakers Digest, 47:34.

Van Buren, J. P., Steinkraus, K. H., Hackler, L. R., El Rawi, I. and Hand, D. B. 1964. Heat Effects of Soy Milk: Indices of Protein Quality in Dried Soy Milks. Journal of Agricultural and Food Chemistry, 52:524-528.

Van Duyne, F. O. 1950. University of Illinois, Extension Service in Agriculture and Home Economics. #662.

Wei, L. S., Berra, R., Nelson, A. I. and Steinberg, M. P. 1973. Canned pork and soybeans. Illinois Research. Spring Issue.

Wheeler, E. H., Titus, M. C. and Van Dyne, F. O. 1960. Thiamin retention in and palatability of soybeans. Amer. Dietetics Assoc. 37 (4):357.

Wilkens, W. F., Mattick, L. R. and Hand, D. B. 1967. Effect of Processing Method on Oxidative Off-Flavors of Soybean Milk, Food Technology, 21:86-89.

Wolf, W. J. and Baker, F. L. 1972. Scanning electron microscopy of soybeans. Cereal Science Today. 17:5.

Wolf, W. J. and Cavan, J. C. 1972. "Soybeans as a Food Source." Chemical Rubber Co. Press. Cleveland, Ohio.

Wolf, W. J. 1966. Trypsin inhibitors, hemaglutinin, saponin and isoflavone of soybean. In "Proceedings of International Conference on Soybean Protein Foods." U.S.D.A.-A.R.S. 71-35. United States Department of Agriculture, Agriculture Research Service, Northern Utilization Research and Development Division, Peoria, Illinois.

United Nations. 1968. Economic and Social Council Advisory Committee on the Application of Science and Technology to Development, Feeding the expanding world population; international action to prevent the impending protein crisis. Report to the Economic and Social Council of the Advancement Committee on the Application of Science and Technology to Development. U. S. Document E (4343) Rev.1 New York.

APPENDIX VI

Research in Food Science

I-A - Effect of Various Processing Steps Using Sodium or Ammonium Bicarbonate on Tenderness and Flavor of Canned Whole Soybeans

Objectives and Experimental Design.

The objectives of the experiment included:

a. Comparison of the effectiveness of ammonium bicarbonate and sodium bicarbonate for tenderizing soybeans.

b. Comparison of the influence of soaking and blanching with or without bicarbonate on soybean tenderness.

c. Effect of storage on canned soybeans at 1, 21 and 38 ^{o}C.

d. The effects of interaction of, (1) concentration of bicarbonate, (2) processing steps used, (3) storage temperature and (4) storage time.

Soybeans were soaked and/or blanched in sodium or ammonium bicarbonate solution. About 150 g rehydrated soybeans were packed in number 1 cans. The cans were filled with 1% NaCl and thermally processed. Twenty-two different combinations of preprocessing conditions were used. Replicates were made on three successive days. Distilled, deionized water was used throughout the experiment. The products were stored for up to 12 months at 3 temperatures. (The 12 month evaluation will be made early in the next contract year).

The canned soybeans were evaluated for:

a. pH of brine
b. Tenderness of LEE-Kramer Shear Press.
c. Tenderness, flavor and off-flavor by organoleptic evaluation.

The analyses were conducted over a 3-day period. Only those samples which were stored at 38°C. were evaluated organoleptically. The results were subjected to an analysis of variance using a computer.

TABLE I. EXPERIMENTAL DESIGN FOR PROCESSING AND STORAGE OF CANNED SOYBEANS.

VARIABLE	TREATMENT LEVEL			
EXPT. I - NH_4HCO_3 at pH 7.5				
A. Concentration of solution (%)	0	0.05	0.15	0.30
B. Soak/blanch	Soak only, blanch only, both soak and blanch.			

Table I con't.

VARIABLE	TREATMENT LEVEL			
C. Storage temperature (°C)	1	21	38	
D. Storage time (weeks)	1	12	24	52

EXPT. II - $NaHCO_3$ at pH 7.5

A. Concentration of solution (%)	0.0	0.30	0.50

B. C. and D. Same as Expt. I.

RESULTS:

Note: The results presented are preliminary. The 12-month analysis will take place early in the next contract year.

"Initial" pH values of the brine were measured 1 week after canning. Either sodium or ammonium bicarbonates resulted in higher initial pH values of the brine in which the soybeans were canned (Figure 1). The pH increased with increasing concentration of either bicarbonate. The pH was higher if the bicarbonate solution was used for both soaking and blanching. The buffering effect of the soybeans was substantial. The pH of the brine after canning dropped to 6.2 - 6.8 even though the NaCl and bicarbonate solutions used were at pH 7.5.

In general, during storage, the pH of the brine decreased (Figures 2-5). However for the control samples prepared without the use of bicarbonate and stored at 1C or 21C, the pH of the brine increased (Figures 4 and 5). During 6 months of storage, the pH of the brine solution tended to shift toward the pH range 6.1 to 6.4. The pH changed faster at higher temperatures. The amount of change in pH depended on several factors; namely (a) use of the bicarbonate solution for soaking only, or blanching only, or for both soaking and blanching, (Figures 4 and 5), (b) the concentration of the bicarbonate solution used for soaking and blanching, (Figures 2 and 3), (c) the temperature of storage, and (d) the storage time (Figures 4 and 5).

Figure 1. pH OF CANNED SOYBEAN BRINE: EFFECT OF SOAKING/BLANCHING WITH $NaHCO_3$ OR NH_4HCO_3

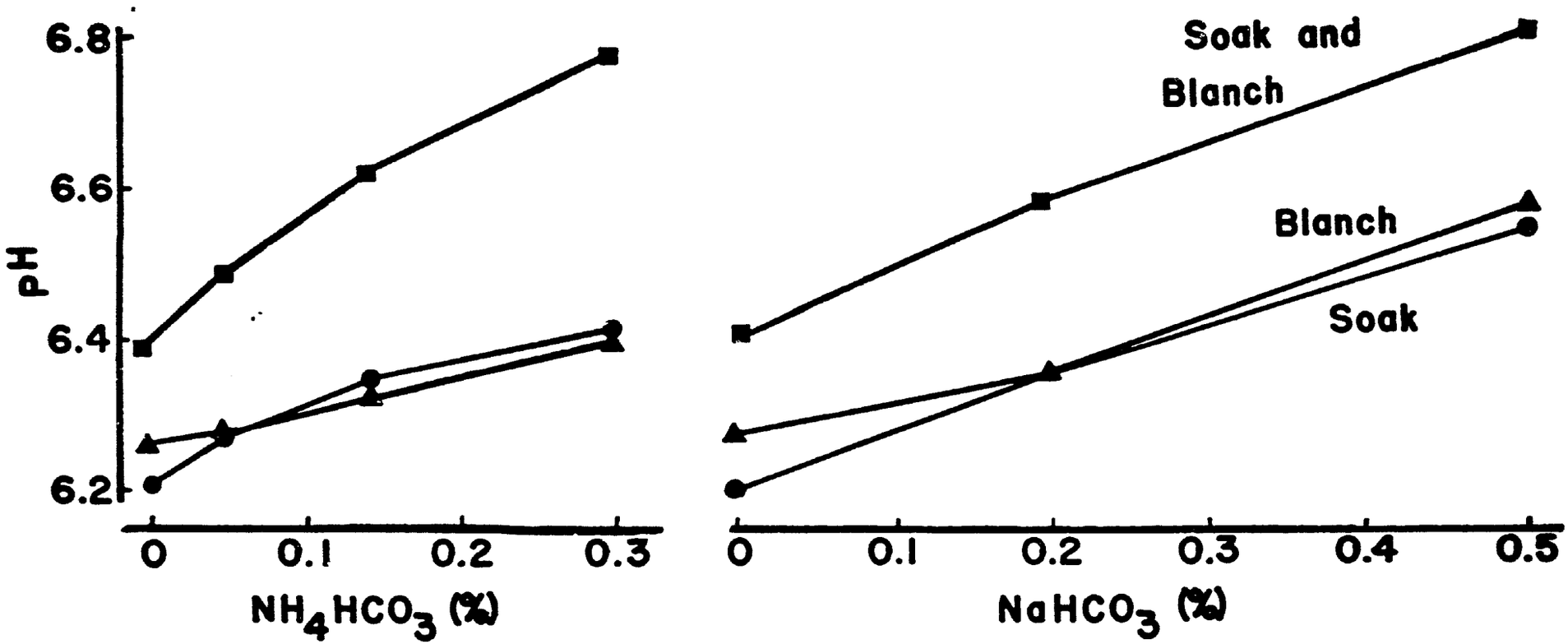


FIGURE 2 EFFECT OF NH_4HCO_3 CONCENTRATION IN SOAK/BRINE SOLUTION ON pH OF BRINE DURING STORAGE OF CANNED SOYBEANS AT 38°C.

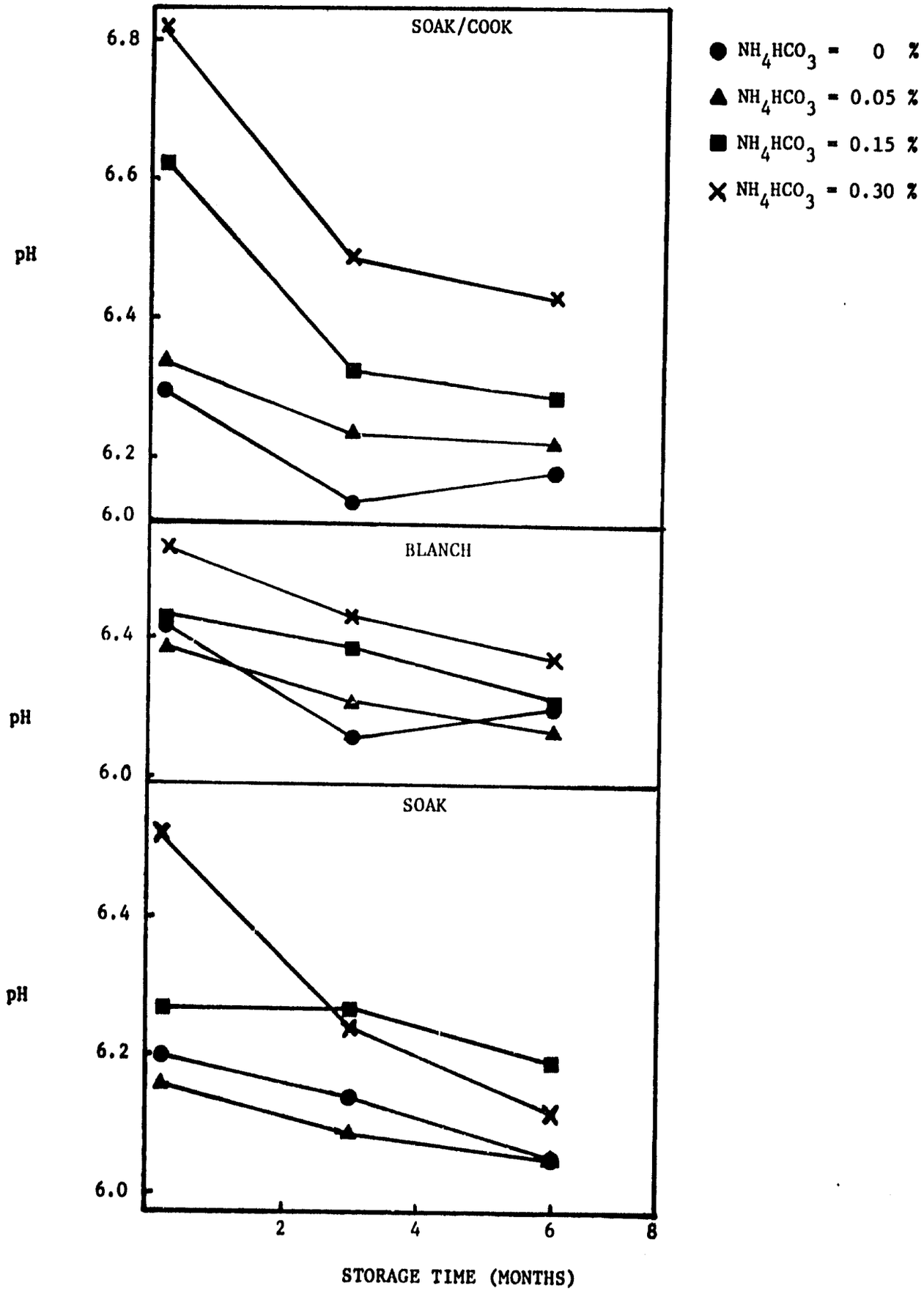


FIGURE 3 EFFECT OF $NaHCO_3$ CONCENTRATION IN SOAK/BLANCH SOLUTION ON pH OF BRINE DURING STORAGE OF CANNED SOYBEANS AT 38°C.

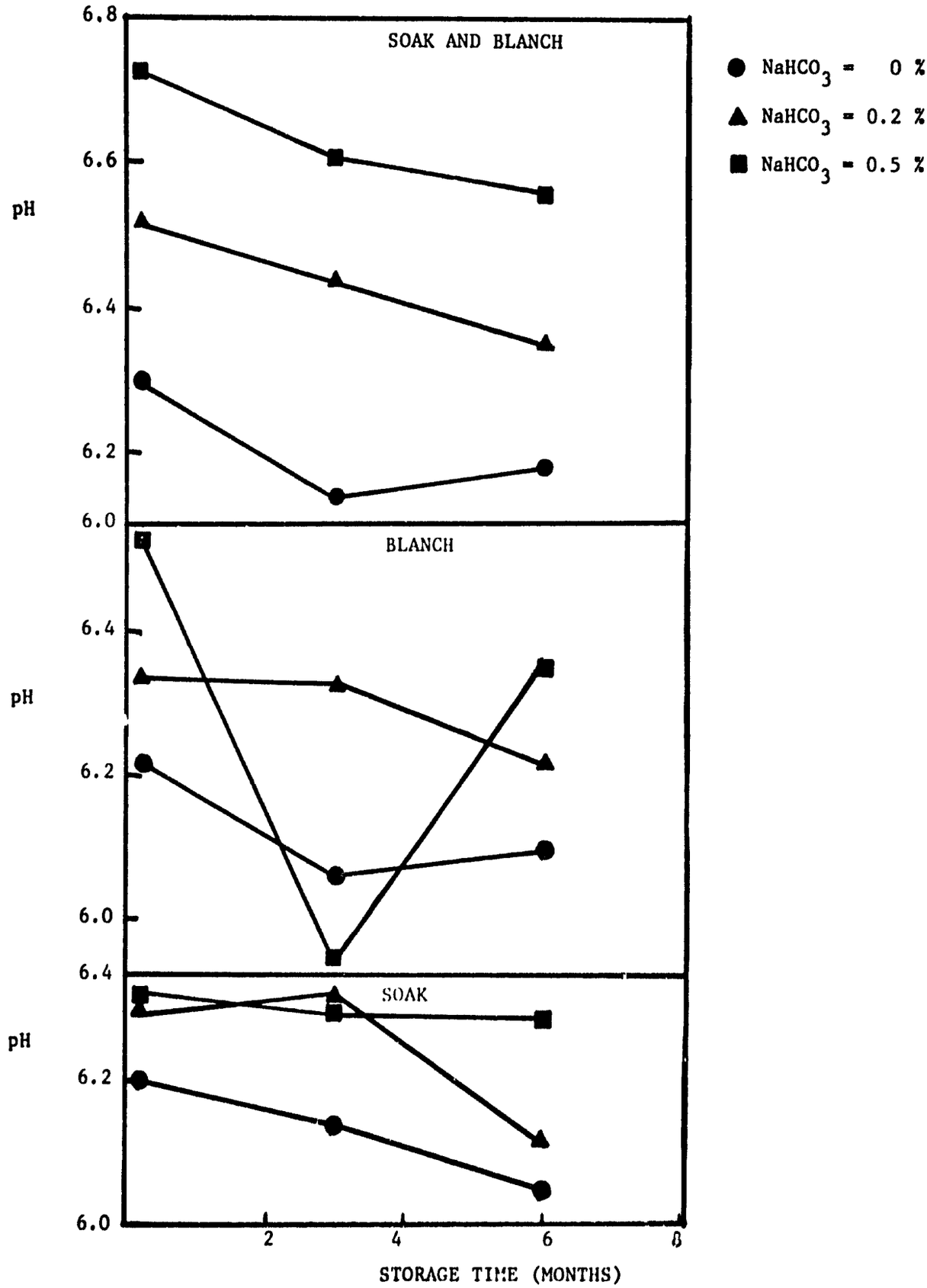


FIGURE 4 EFFECT OF NH_4HCO_3 CONCENTRATION IN SOAK SOLUTION ON pH OF BRINE DURING STORAGE OF CANNED SOYBEANS.

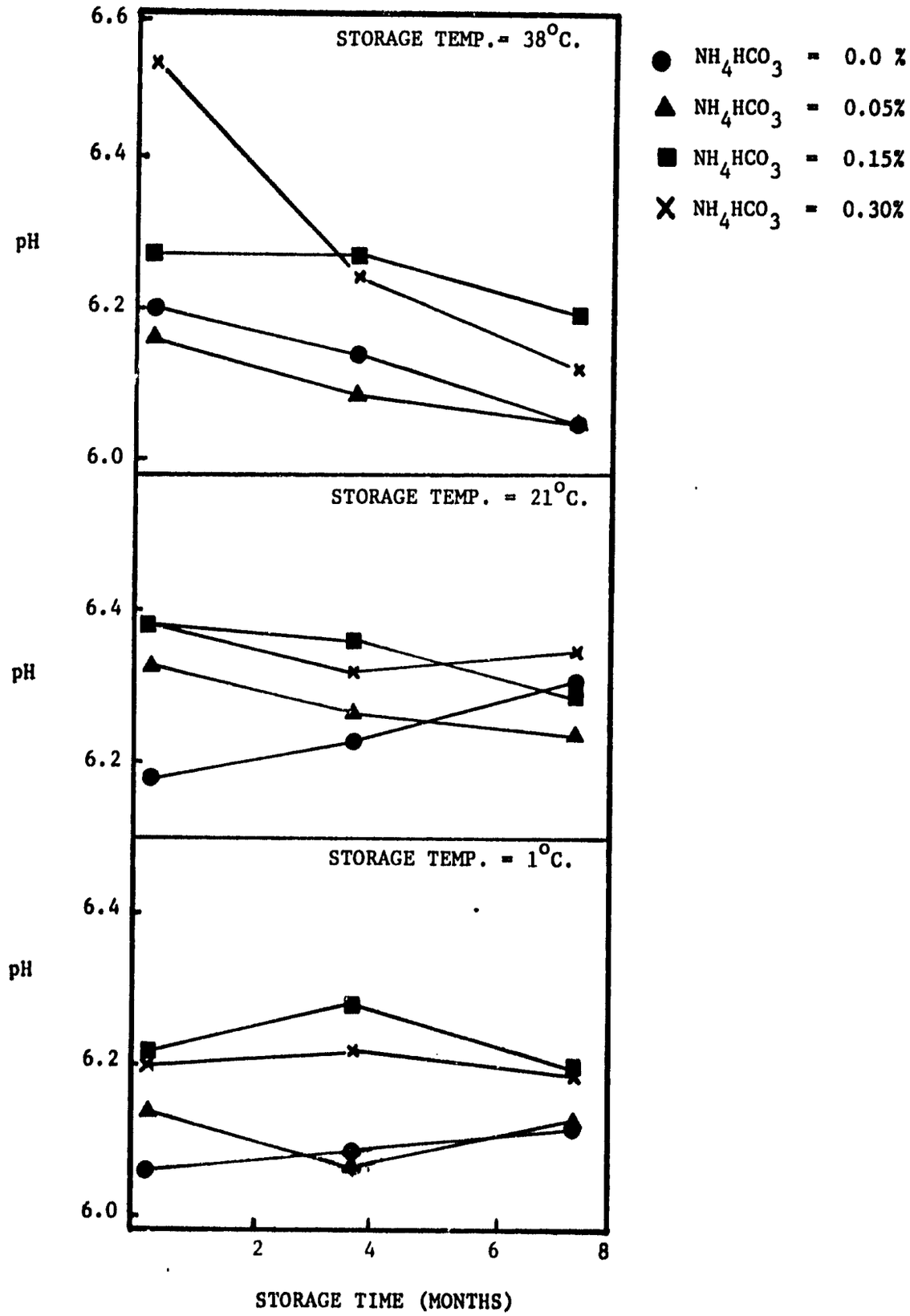
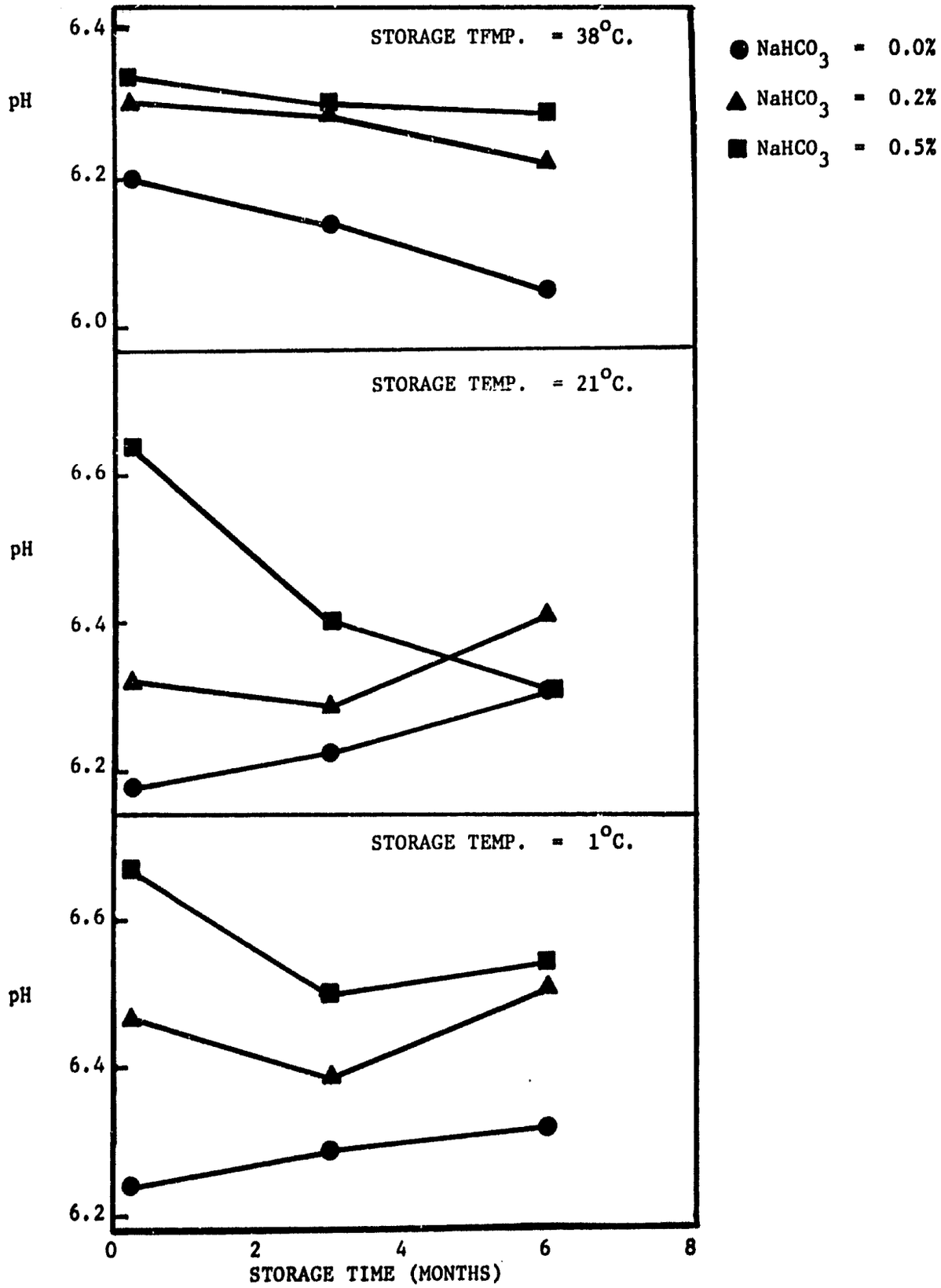


FIGURE 5 EFFECT OF $NaHCO_3$ CONCENTRATION IN SOAK SOLUTION ON pH OF BRINE DURING STORAGE OF CANNED SOYBEANS.



EFFECT ON TENDERNESS

Initial values for tenderness were very much affected by the type of processing treatment, Figure 6. Soaking and blanching, or soaking only, resulted in a more tender bean than blanching only. The tenderness was also dependent upon the concentration of the bicarbonate solution and on the type of bicarbonate solution used. Note that ammonium bicarbonate is more effective than sodium bicarbonate. The effect of concentration was not linear. Soaking in distilled, deionized water resulted in the most tender beans.

During storage, the firmness of the soybeans increased as a general rule (Figures 7-10). The degree of increase in firmness, did not seem to be affected by the temperature of storage between 1°C and 38°C. Soybeans which were blanched with bicarbonate before canning had larger changes in tenderness than those which were soaked in bicarbonate solution before canning. Soybeans processed with NH_4HCO_3 had slightly smaller changes in tenderness than those processed in water only. Statistical analysis did show that there were several minor interactions between these factors which influenced the change in tenderness of the soybeans during storage. These interactions will be discussed in next year's report.

EFFECT ON ORGANOLEPTIC ANALYSIS

Organoleptic analysis of the canned soybeans showed that no significant changes in flavor or off-flavor were detected as a result of treatment of the soybeans with sodium or ammonium bicarbonate at any of the concentrations used or at any of the storage temperatures or storage times evaluated to date. Furthermore, except for those caused by the soak/blanch processing treatment, the taste panelists could not distinguish between changes in tenderness which might have occurred in the soybeans. Mean organoleptic scores are shown in Tables (II) and (III). In general, soaking and blanching with bicarbonate solutions resulted in the most tender soybeans and blanching only in the least tender soybeans.

1-B - The Effect of Mixtures on Sodium and Ammonium Bicarbonate for Tenderizing Soybeans

Objective and Experimental Design.

An experiment was designed to test the effect of mixtures of sodium and ammonium bicarbonate for tenderizing soybeans.

All soybeans were soaked and blanched in tap water or softened water or distilled, deionized water. In each case either the soak water or the blanch water had a mixture of $NaHCO_3$ plus NH_4HCO_3 added to it. Thus, for example, two successive samples would be treated as follows:

a. Soak in tap water, blanch in tap water containing 0.01% NH_4HCO_3 + 0.1% $NaHCO_3$.

b. Soak in tap water containing the same bicarbonate mixture as in (a), blanch in tap water.

Figure 6. TENDERNESS OF CANNED SOYBEANS: EFFECT OF PROCESSING WITH NH_4HCO_3 OR $NaHCO_3$ SOLUTIONS

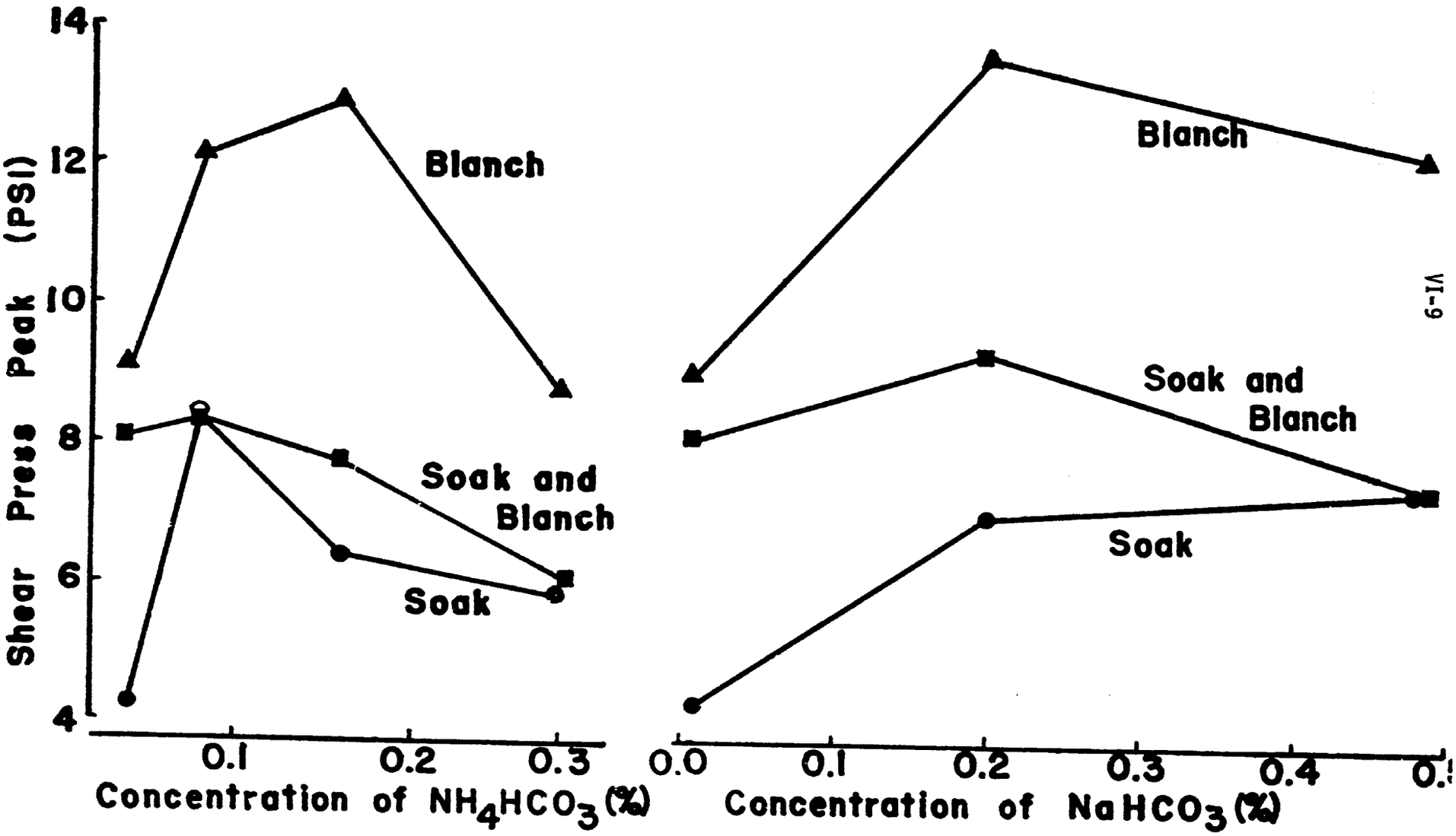


FIGURE 7 CHANGE IN TENDERNESS DURING STORAGE AT 38°C: EFFECT OF SOAK/BLANCH WITH NH_4HCO_3 SOLUTION.

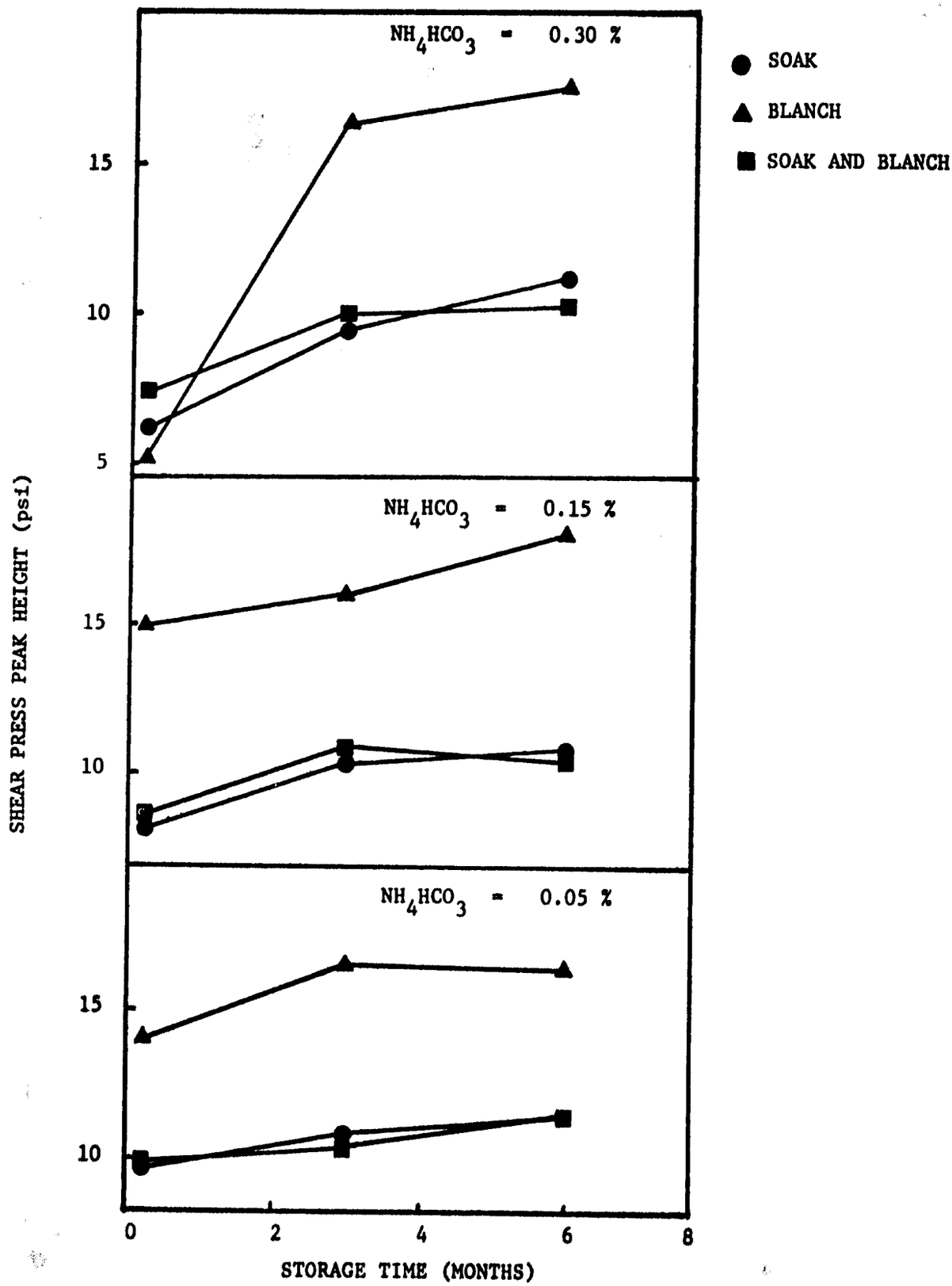


FIGURE 8 CHANGE IN TENDERNESS DURING STORAGE AT 38°C: EFFECT OF SOAK/BLANCH

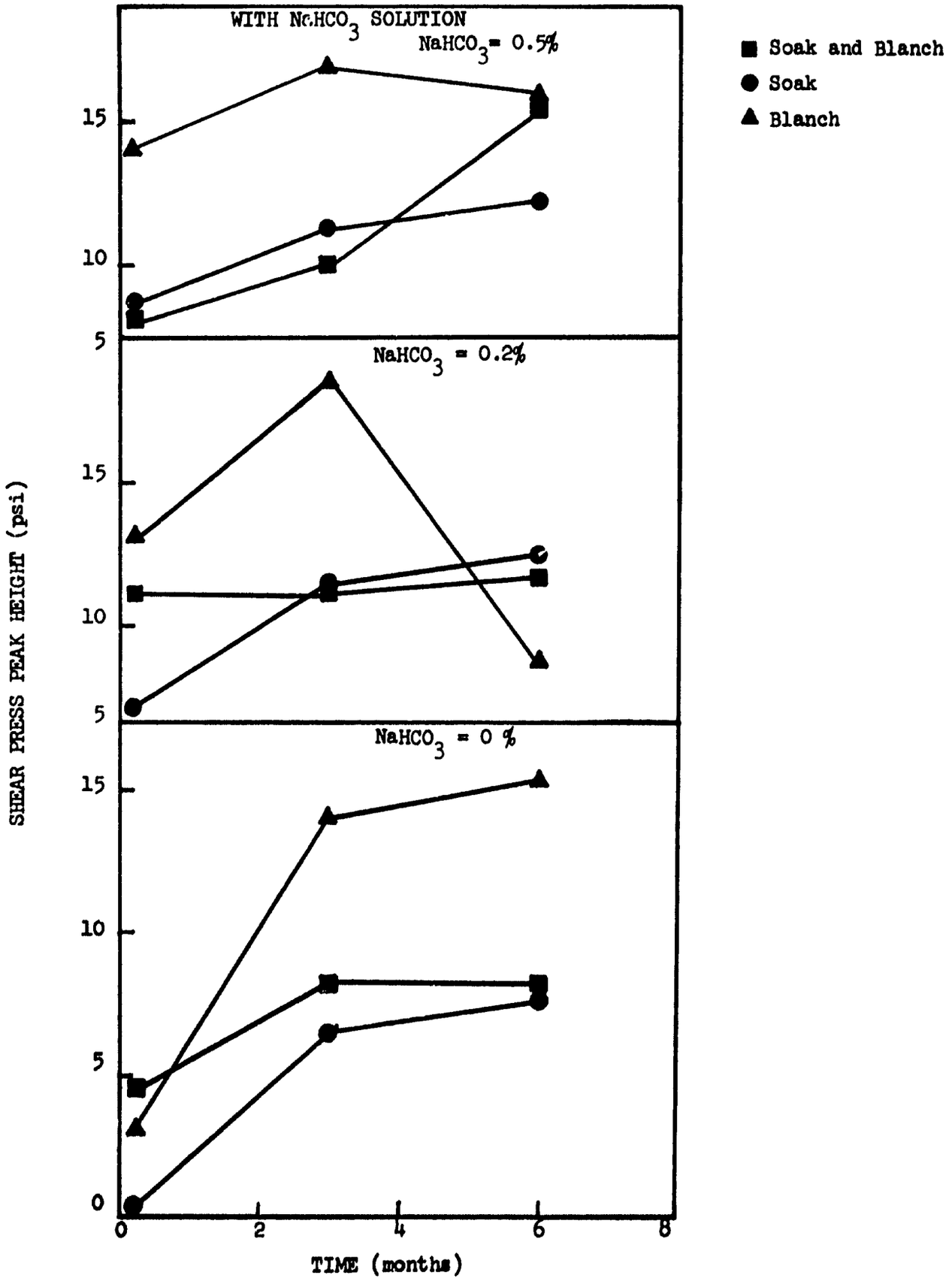


FIGURE 9 CHANGE IN TENDERNESS DURING STORAGE: EFFECT OF STORAGE TEMPERATURE AND NH_4HCO_3 CONCENTRATION IN SOAK SOLUTIONS

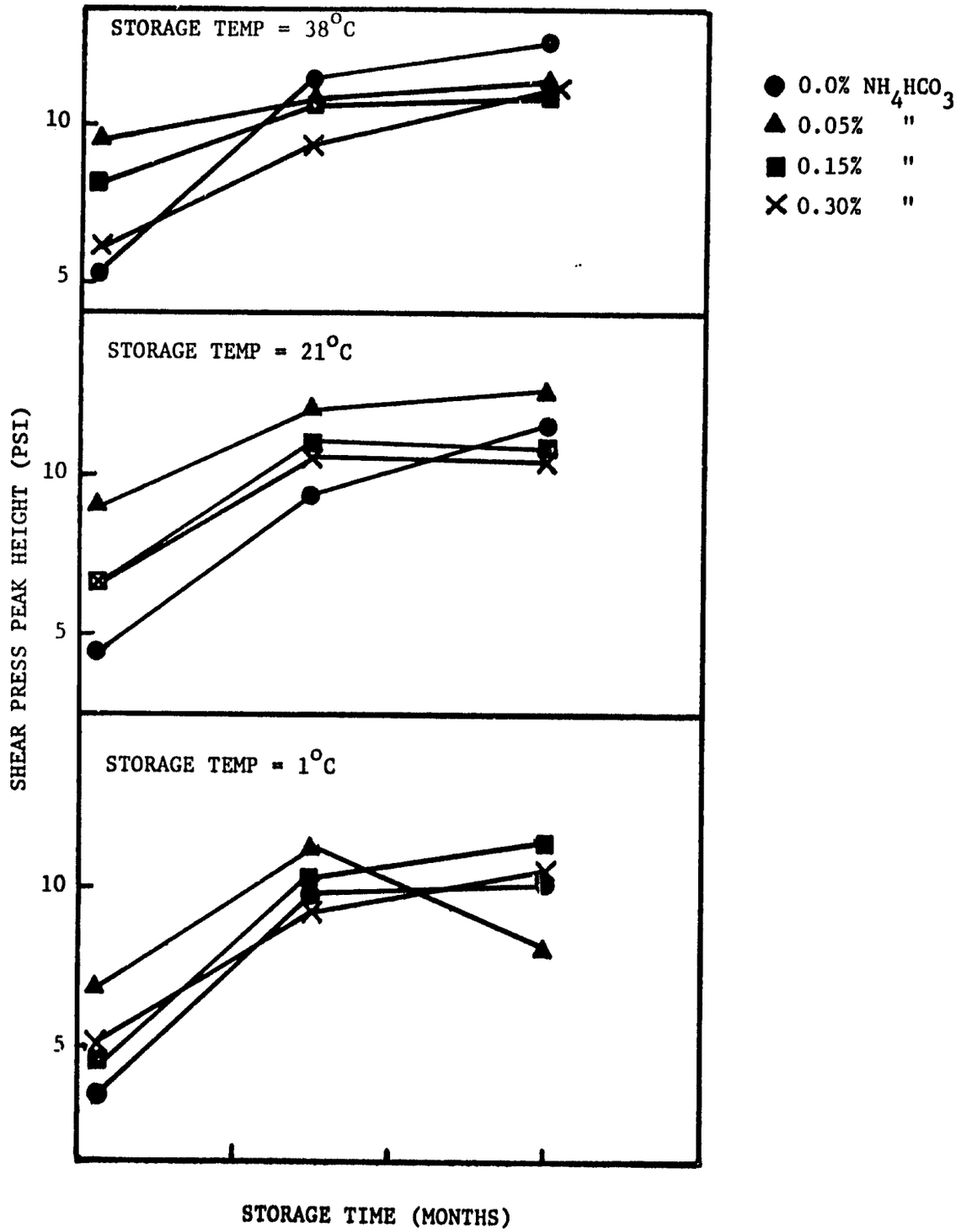


FIGURE 10 CHANGE IN TENDERNESS DURING STORAGE: EFFECT OF STORAGE TEMPERATURE AND $NaHCO_3$ CONCENTRATION IN SOAK SOLUTION.

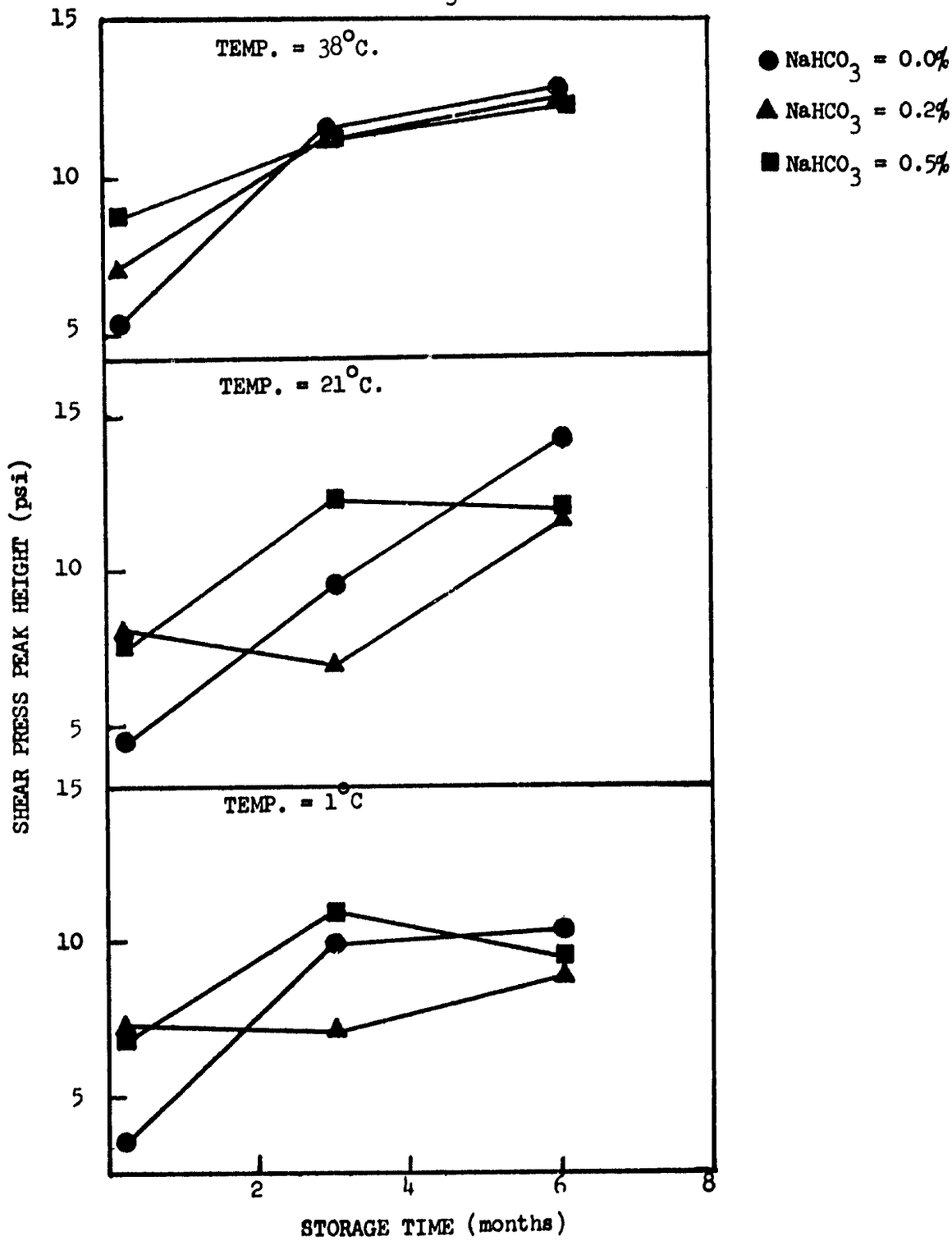


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TABLE II. MEAN ORGANOLEPTIC SCORES FOR SOYBEANS PROCESSED WITH NH_4HCO_3, CANNED, AND STORED AT 38°C.

BICARBONATE CONCENTRATION (%)	PROCESSING POINT	MEAN ORGANOLEPTIC SCORES		
		TIME (WEEKS) 1	12	24
0	Soak and blanch	7.2	8.1	7.7
	Soak	6.7	7.3	7.1
	Blanch	6.7	6.8	6.6
0.05	Soak and blanch	7.9	7.0	8.0
	Soak	7.1	7.5	7.3
	Blanch	6.3	6.5	6.7
0.15	Soak and blanch	7.5	7.4	8.1
	Soak	7.3	6.7	7.4
	Blanch	5.8	6.4	6.2
0.30	Soak and blanch	6.8	8.1	8.1
	Soak	7.4	7.2	7.2
	Blanch	7.0	5.7	5.9

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TABLE III: MEAN ORGANOLEPTIC SCORES FOR SOYBEANS PROCESSED WITH $NaHCO_3$, CANNED, AND STORED AT 38°C.

BICARBONATE CONCENTRATION (%)	PROCESSING POINT	MEAN ORGANOLEPTIC SCORES		
		TIME (WEEKS) 1	12	24
0	Soak and blanch	7.2	8.1	7.7
	Soak	6.7	7.3	7.1
	Blanch	6.7	6.8	6.6
0.2%	Soak and blanch	7.2	7.5	7.7
	Soak	7.6	6.7	6.7
	Blanch	6.2	6.1	7.9
0.5%	Soak and blanch	7.7	7.7	6.0
	Soak	7.4	7.0	6.7
	Blanch	7.2	6.3	6.0

Soybeans were canned after soaking and blanching in the designated solutions. All the soybeans were packed in 1% sodium chloride solution before thermal processing. The products were evaluated for tenderness after two days and after six weeks by using a LEE-Kramer shear press. The experimental design is outlined in Table IV. In all, there were 60 combinations of conditions and two storage times. Duplicate cans were tested for tenderness using an Instron shear press.

TABLE IV. TENDERNESS OF SOYBEANS TREATED WITH A MIXTURE OF SODIUM AND AMMONIUM BICARBONATE

VARIABLES	TREATMENT LEVELS
Types of water	Tap, softened, deionized.
Processing method	Soak, blanch in designated bicarbonate solution
Bicarbonate mixtures	NH_4HCO_3 (%) + $NaHCO_3$ (%)
pH = 7.5 in all cases.	

0	+	0
0.01	+	0.0
0.01	+	0.001
0.01	+	0.01
0.01	+	0.1
0.0	+	0.01
0.001	+	0.01
0.01	+	0.01
0.1	+	0.01

Note: Soybeans were packed and thermally processed in 1% NaCl using the same type of water as was used for soaking and blanching.

RESULTS:

This experiment was designed to test in more detail a single earlier observation that a mixture of sodium and ammonium bicarbonate had a synergistic effect as a tenderizing agent. If true, then much lower concentrations of bicarbonates could be used. This did not prove to be the case in these detailed experiments (Table V). No significant differences in tenderness were found as a result of using the mixtures of bicarbonates tested. This was completely unexpected and contradictory to the earlier result.

TABLE V - EFFECT OF MIXTURES OF $NaHCO_3$ and NH_4CO_3 on TENDERNESS OF CANNED SOYBEANS*

CONCENTRATION OF NH_4HCO_3(%) + $NaHCO_3$(%)	SOAK OR BLANCH** WITH BICARBONATE	SHEAR PRESS PEAK HEIGHTS (kg/cm^2) TYPE OF WATER: SOFT WATER	TAP WATER	DEIONIZED WATER
0 + 0	Soak and blanch	1.33	1.33	1.12
0.01 + 0	Soak	1.35	1.34	1.20
	Blanch	1.38	1.31	-
0.01 + 0.001	Soak	1.35	1.34	1.22
	Blanch	1.39	1.36	1.23
0.01 + 0.01	Soak	1.39	1.27	1.22
	Blanch	1.36	1.32	1.23
0.01 + 0.1	Soak	1.35	1.34	1.25
	Blanch	1.30	1.37	1.26
0 + 0.01	Soak	1.29	1.34	1.19
	Blanch	1.34	1.34	1.22
0.001 + 0.01	Soak	1.34	1.29	1.30
	Blanch	1.31	1.36	1.22
0.1 + 0.01	Soak	1.34	1.29	1.24
	Blanch	1.34	1.32	1.22

* Wayne variety 1973 crop.

** All beans were both soaked and blanched using type of water indicated. Bicarbonate was added to soak or blanch water as stated in this column.

II-A - Water Uptake by Soybeans at Different Temperatures

Objectives and Experimental Design

This experiment was designed to determine the effect of different soaking temperatures and solutions on water uptake of soybeans. The purpose was to find the fastest and best conditions for highest uptake of water.

Observations were made on rate and amount of water uptake of soybeans using four samples of beans, four different solutions, and six soaking temperatures. Change in weight was observed until the soybeans reached maximum weight. Loss of solids from the beans was not measured. The experimental design is given in Table VI.

TABLE VI WATER UPTAKE OF SOYBEANS

VARIABLE	TREATMENT LEVEL
Soybean variety and year	Wayne 1973, Wayne 1974, Kanrich 1973, Kanrich 1974
Soaking solution	Deionized H_2O, softened H_2O, tap H_2O, 0.01% $NaHCO_3$, 0.5% $NaHCO_3$ (All at pH 7.5)
Temperature of soaking solution. ^oC.	25 40 50 60 70 95

RESULTS:

The influence of the type of water, the temperature and added bicarbonate, upon the rate and amount of water uptake by four samples of soybeans was observed. A family of curves for two varieties of soybeans using one solution is shown in Figures 11 and 12. From many curves similar to those in Figures 11 and 12, it was possible to construct curves as shown in Figures 13 and 14. These show the influence of temperature upon rate of and amount of water uptake. Rate of water uptake increased rapidly up to about 60°C and then very slowly as the temperature was raised to 95°C. The amount of water uptake decreased as the temperature of the soak water increased.

FIGURE 11 WEIGHT GAIN BY WAYNE VARIETY SOYBEANS SOAKED IN TAP WATER

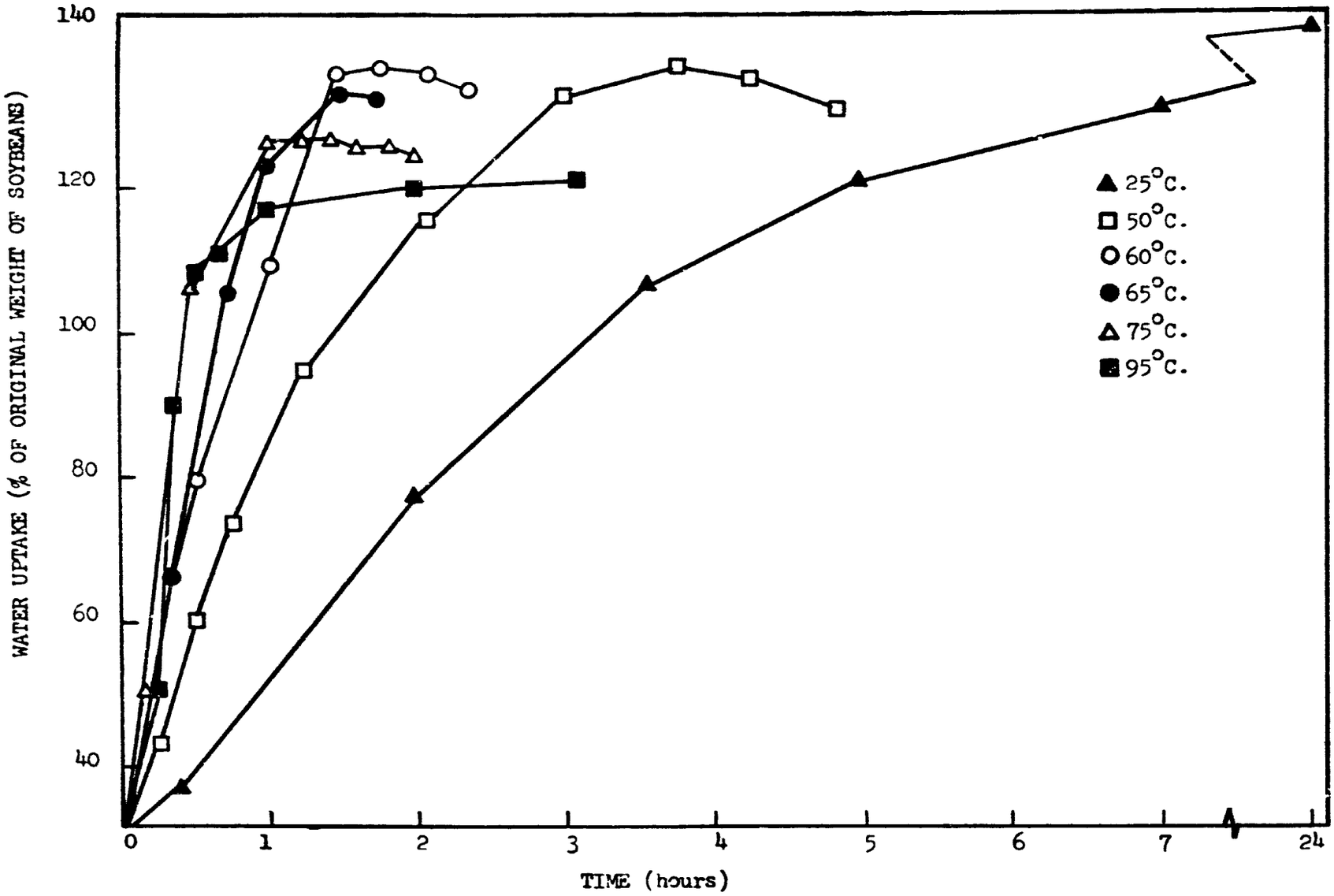


FIGURE 12 WEIGHT GAIN BY KANRICH VARIETY SOYBEANS SOAKED IN TAP WATER

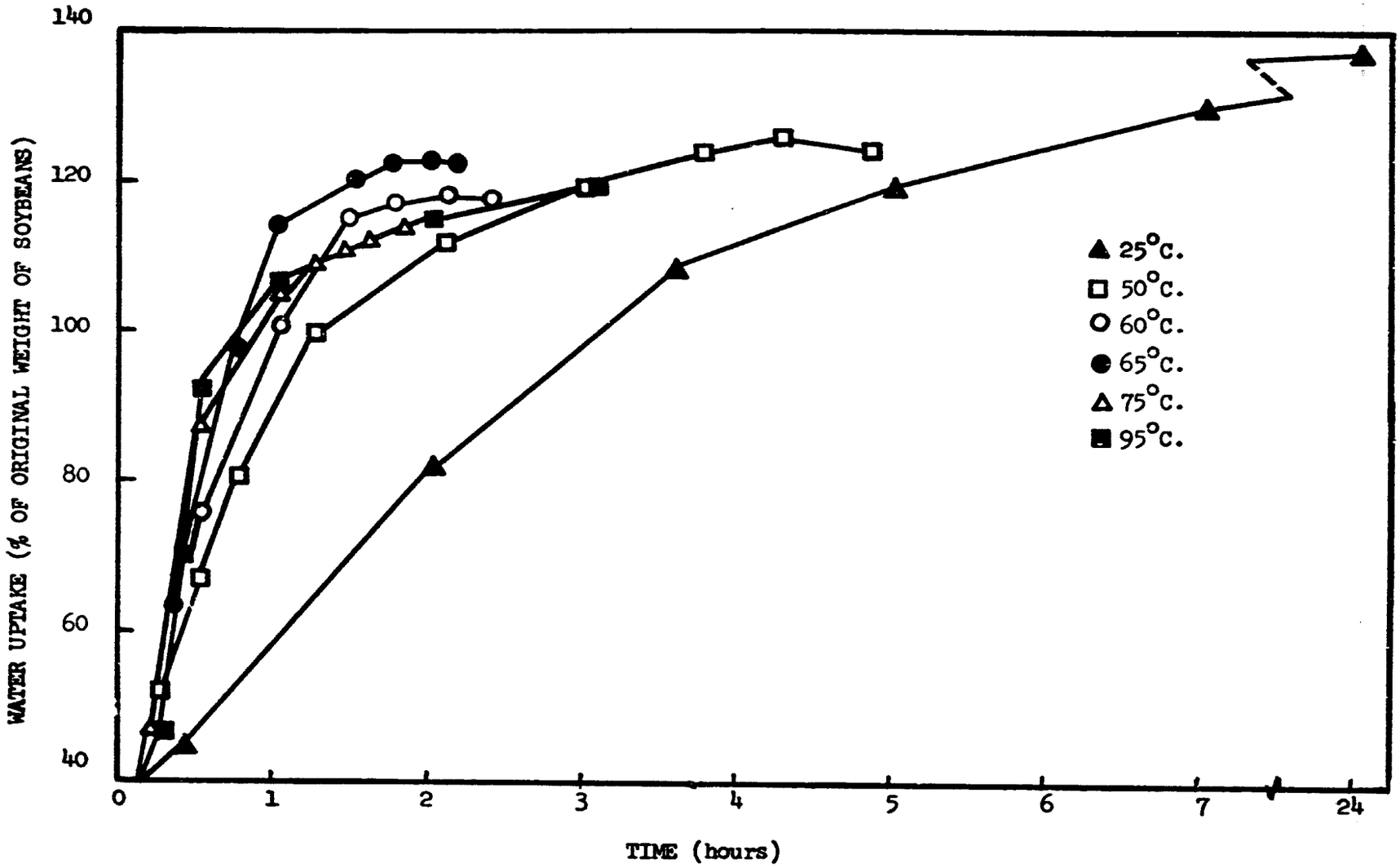


FIGURE 13 RATE OF WATER REGAIN BY SOYBEANS AS AFFECTED BY TEMPERATURE

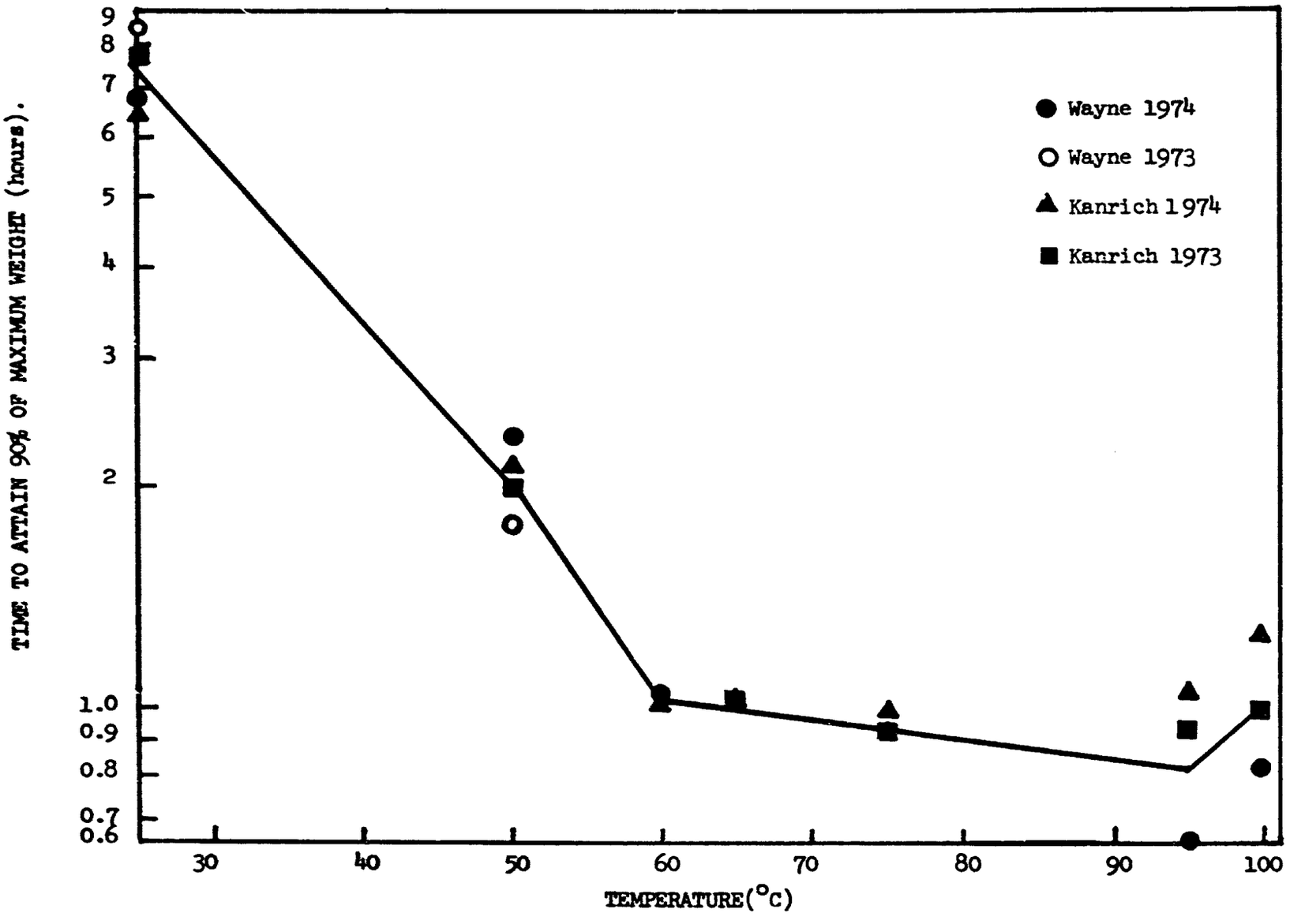
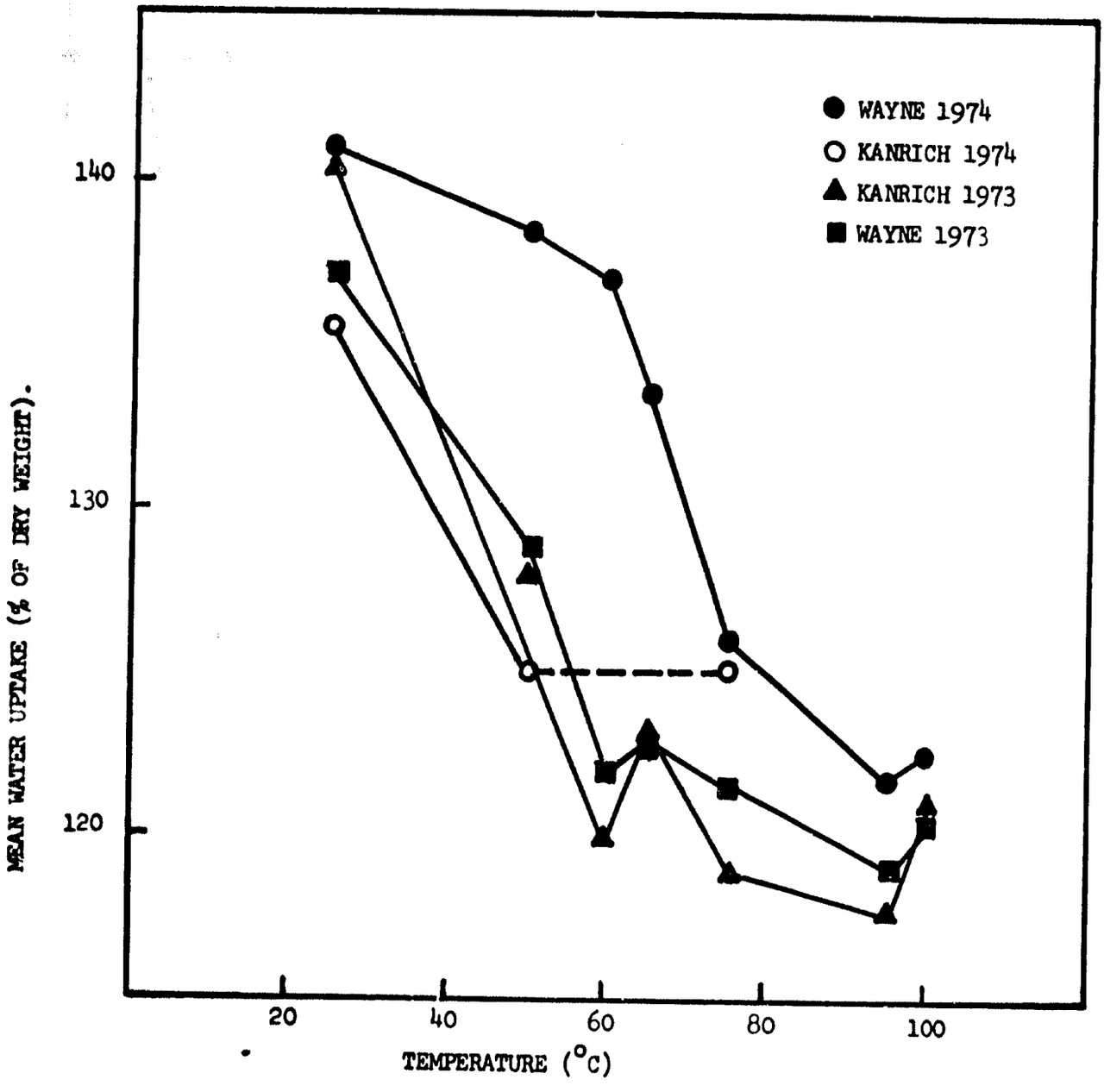


FIGURE 14 MAXIMUM WATER UPTAKE OF SOYBEANS AS AFFECTED BY TEMPERATURE



II-B - Influence of Variety on Tenderness of Cooked Soybeans

Objective and Experimental Design.

The purpose of this experiment was to find a rapid soaking/cooking technique for estimating tenderness of different varieties of soybeans.

Eight varieties of soybeans were treated with eight combinations of soaking and cooking conditions as shown in Table VII. Water uptake was measured after soaking and duplicate shear press (tenderness) values were determined after cooking for 60 minutes. Tenderness values were subjected to an analysis of variance.

TABLE VII. EFFECT OF VARIETY, SOAKING AND COOKING ON SOYBEAN TENDERNESS

VARIABLES	TREATMENT LEVEL
Soybean variety	8 varieties grown in 1974
Solution used	Tap H_2O deionized H_2O 0.4% NH_4HCO_3 in tap water, 0.4% $NaHCO_3$ in tap water. (All at pH 7.5)
Soak/cook conditions	1. No soak; cook for 60 min. 2. Overnight soak at room temp, cook for 60 min. 3. 1 hour soak at 60°C; cook for 60 min.

Note: This results in 32 soak/cook/solution treatments for each variety.

RESULTS:

Eight varieties of soybeans were tested using 3 different soak/blanch combinations and four aqueous solutions. Tenderness values are given (Tables VIII-X). An analysis of variance indicated that all three variables tested were significant at the 99.9% level. The importance of the variables may be ranked (a) soak/blanch conditions, (b) solutions used and (c) variety.

When the varieties of soybeans were ranked in the order most tender to least tender, the ranking of varieties was dependent upon soak/blanch conditions and the solution used. (Compare Tables VIII-X) In general, the use of bicarbonate resulted in softer cooked soybeans, and longer soak times resulted in softer cooked soybeans. However, no consistent basis for predicting tenderness of different varieties was observed.

TABLE VII: EFFECT OF VARIETY AND BLANCH SOLUTION ON TENDERNESS OF SOYBEANS BLANCHED WITHOUT SOAKING.

SHEAR PRESS PEAK HEIGHT (psi)

	BLANCH SOLUTION				
VARIETY	DISTILLED WATER	TAP WATER	TAP WATER + 0.4% $NaHCO_3$	TAP WATER +0.4% NH_4HCO_3	ALL SOLUTIONS MEAN
Hardee	55	59	76	37	57
Pickett	OS *	-	51	68	59
Wayne	89	49	61	56	64
Kanrich	-	50	74	70	64
Williams	73	75	60	50	65
Hill	92	76	49	61	69
Ozonishiki	-	OS	72	-	71
Davis	91	89	OS	74	84

*OS = Off Scale

TABLE IX. EFFECT OF VARIETY AND SOAK/BLANCH SOLUTION ON TENDERNESS OF SOAKED AND COOKED SOYBEANS.

SHEAR PRESS PEAK HEIGHT (psi)

	SOAK/BLANCH SOLUTION *				
VARIETY	DISTILLED WATER	TAP WATER	TAP WATER + 0.4% $NaHCO_3$	TAP WATER + 0.4% NH_4HCO_3	ALL SOLUTION MEAN
Wayne	58	33	21	24	34
Kanrich	55	30	24	27	34
Williams	55	30	24	27	36
Ozonishiki	-	42	32	-	37
Hardee	39	45	61	20	41
Hill	67	49	25	23	41
Pickett	58	52	33	31	44
Davis	64	61	61	35	55

*Soybeans were soaked overnight in about 3 volumes of solution and then blanched for 60 minutes at 100°C in fresh solution.

TABLE X EFFECT OF VARIETY AND SOAK/BLANCH SOLUTION ON TENDERNESS OF SOAKED AND COOKED SOYBEANS.

SHEAR PRESS PEAK HEIGHT (psi)

	SOAK/BLANCH SOLUTION*				
VARIETY	DISTILLED WATER	TAP WATER	TAP WATER +0.4% $NaHCO_3$	TAP WATER +0.4% NH_4HCO_3	ALL SOLUTIONS MEAN
Wayne	68	42	24	26	40
Kanrich	70	31	32	28	40
Williams	48	62	28	27	41
Ozonishiki	-	57	31	-	44
Hardee	37	57	72	20	47
Hill	75	63	24	32	49
Pickett	82	90	26	40	59
Davis	70	67	68	38	61

*Soybeans were soaked in the designated solution at 60°C for 60 minutes and then blanched for 60 minutes at 100°C. in fresh solution.

III - Nutritional Evaluations of Soy-Cereal and -Fruit Mixes

Experimental Design.

Protein efficiency ratios (PER) were determined on a number of food prototypes made wholly or partly with full fat soybeans. Such tests were expected to indicate the potential of using soy cereal or soy fruit mixtures and to demonstrate nutritional advantages or drawbacks of certain processing methods. For soybean cereal mixtures, the ratio of soy to cereal was selected to give a content of methionine which was as close as possible to FAO recommended standards. The feeding studies were conducted by the Department of Dairy Science, University of Illinois. Weanling Sprague-Dawley male rats were fed for 28 days in accordance with good standard practice. Diets all contained 10% protein and were isocaloric to 6.0% soybean oil. Diets and soy:cereal combinations are given in Tables XI and XII.

TABLE XI. DIET COMPOSITION

CERELOSE[a]	25.14
PROTEIN PRODUCT[b]	-----
SOYBEAN OIL[c]	-----
SALT MIXTURE	4.00
VITAMIN MIXTURE	1.00
TOCOPHEROL ACETATE (20 MG/KG)	+
SANTOQUIN (125 MG/KG)	+
	100.00

[a]All substitutions at the expense of cerelose.

[b]All diets fed at 10.00% protein excepting D.E.W. (dried egg white) fed also at 5.0 and 7.5% protein.

[c]Iso-caloric to 6.0% soybean oil.

10 male rats/treatment (Sprague Dawley Strain)

Weight range 47-53 g.

TABLE XII. COMPOSITION OF SOY CEREALS

MIXTURE	RATIO	CALCULATED % PROTEIN	CEREAL SOURCE
Soy:Corn	1.3	17	Commercial Corn Meal
Soy:Rice	1:1	25	Japonica
Soy:Wheat	1:1	26	Commercial Whole Wheat Flour
Soy:Millet	2:1	33	Proso (White)
Soy:Barley	1:1	25	Commercial Pearled Barley
Soy:Rye	1:1	25	Commercial Rye Flour
Soy:Potato	1:1	24	Idaho Russet
Soy Beverage Base	-	40	

WAYNE 73 SOYBEANS WERE USED IN ALL CASES.

RESULTS:

Protein efficiency ratios were determined for a number of mixtures containing whole soybeans. (For study 2 PER values were adjusted so that casein had a PER of 2.50).

Mixtures and PER's obtained are shown in Tables XIII and XIV. Note that the PER's for all soy:cereal mixtures in Study 2 (Table XIV) were between 2.2 and 2.4. Whole soybeans in various forms had PER's of about 2.0 and soy: banana had an unadjusted PER of 1.4. When the soybean and banana were dried separately and then mixed, the PER rose to the same level as that for whole soybeans. The addition of 0.4% methionine to the soybean:banana mixture did not improve the protein efficiency ratio of that mixture. Addition of methionine to whole soy or soy:corn improved the PER.

TABLE XIII PROTEIN EFFICIENCY RATIOS OF SOY MIXTURES - STUDY 1

MIXTURE	AVERAGE WEIGHT GAIN (g)	AVERAGE FEED CONSUMED (g)	P. E. R.
Non-fat dry milk	123.2	386.7	3.19
Non-fat dry milk + met.	154.3	408.1	3.78
No Protein	-14.5	131.2	-
5% Egg White	25.2	200.0	1.26
7.5% Egg White	62.4	261.1	2.39
10% Egg White	125.3	364.9	3.43
10% Egg White + met.	118.6	336.7	3.52
Soy corn (1:3)	98.7	355.6	2.78
Soy corn (1:3) + met.	102.9	353.7	2.91
Whole soy	93.7	359.7	2.60
Whole soy + met.	151.2	412.9	3.66
Soy beverage base	72.9	352.9	2.07
Soy beverage base + met.	145.4	426.6	3.41
Soy banana (1:1)	36.1	262.6	1.37
Soy banana (1:) + met.	37.3	255.9	1.46

TABLE XIV. PROTEIN EFFICIENCY RATIOS OF SOY MIXTURES - STUDY 2

MIXTURE	AVERAGE WEIGHT GAIN (g)	AVERAGE FEED CONSUMED (g)	P. E. R.	ADJUSTED P. E. R.
Non-fat dry milk	125.7	426.3	2.95	2.48
Casein	117.7	396.7	2.97	2.50
No Prot.	-14.7	148.9	-	-
Soy:corn (1:3)	119.7	425.2	2.82	2.37
Soy:rice (1:1)	124.7	436.7	2.86	2.41
Soy:wheat (1:1)	103.3	385.2	2.68	2.26
Soy:millet (2:1)	109.3	417.3	2.62	2.21
Soy:barley (1:1)	124.4	435.0	2.86	2.41
Soy:rye (1:1)	110.3	419.6	2.63	2.21
Soy:potato (1:1)	89	386.5	2.30	1.94
Soy + banana (1:1)*	94.7	407.8	2.32	1.95
Soy beverage	88.4	384.7	2.30	1.94

*Dried separately and mixed after drying.

CONCLUSIONS - PARTS I - III

Part I-A - Use of Bicarbonates for Processing Soybeans.

1. Both sodium bicarbonate and ammonium bicarbonate can be used to tenderize soybeans before canning. The effect of bicarbonates depends upon their concentration and the processing steps during which they are used.
2. Use of either of the bicarbonates only during soaking is more effective than only during blanching. Treatment only during soaking is as effective as treatment during both soaking and blanching.
3. The tenderness of the blanched soybean varies with the bicarbonate concentration used. Maximum tenderness was obtained with use of the highest concentration of the bicarbonate. However, soybeans treated with distilled water were also very tender.
4. Taste panelists detected no significant difference in flavor or off-flavor as a result of the use of bicarbonates. Soaking appeared to be the processing step which most effectively tenderized the soybeans as observed by taste panelists and as measured by shearpress.
5. The use of bicarbonates during soaking and/or blanching increased the pH of the brine in which the soybeans were canned and higher concentrations of bicarbonate resulted in a higher pH. The pH of all products was in the acceptable range, i. e., 6.1 to 6.8, even though the bicarbonate solutions used always had a pH of 7.5.
6. During storage the canned soybeans became less tender as measured by LEE Kramer shear press. The decrease in tenderness was greater at higher storage temperatures. When bicarbonates were used, the decrease in tenderness was less than when bicarbonates were not used.
7. Taste panelists did not detect any changes in tenderness, flavor or off-flavor during storage.
8. The pH of the brine changed during storage. In general, the brine tended to approach the pH range 6.1 to 6.3. The change of pH was more rapid at higher temperatures.

Part I-B - Use of Mixtures of Sodium and Ammonium Bicarbonates for Soaking or Blanching Soybeans.

1. No synergistic effect was detected when ammonium and sodium bicarbonat mixtures were used to process soybeans.

Part II-A - Water Uptake by Soybeans.

1. Temperature was the most important factor which determined the rate of water uptake by soybeans. A plot of rate of water uptake versus temperature indicates a biphasic curve with a sharp break at approximately 60°C. Up to 60°C. the rate of water uptake increased, while between 60 and 90°C. the rate of water uptake was nearly constant.

2. The amount of water uptake was lowered by temperature and by the presence of bicarbonate in the solution in which the beans were placed.

3. There was no significant difference in the amount of water uptake of year-old and freshly harvested Kanrich soybeans.

4. The percentage of water uptake of Kanrich beans was less than the percentage of water uptake of Wayne beans. This effect is probably due to difference in size of the beans.

Part II-B - Effect of Variety Upon Tenderness of Cooked Soybeans.

1. The tenderness of cooked soybeans was increased by longer soaking times and use of bicarbonate in the soak and blanch solution.

2. Varieties exhibited substantial differences in tenderness (shear press) after cooking. However, no variety was consistently more tender than the others for all solutions used or under all soak conditions.

3. No method was found which allows prediction of tender varieties of soybeans.

Part III - Nutritional Evaluations.

1. Mixtures of soy-cereal in simple combinations such as 1-1 or 2-1 resulted in increased PER's compared with whole soybeans.

2. Addition of methionine improved the PEP's of soy-cereal mixtures.

3. Drum-dried soy-banana mixtures had a low PER. The low PER probably resulted from interaction of amino acids and reducing sugars. Addition of methionine to soy-banana mixtures, did not improve the PER.

Part IV - Village Level Processing of Soybean Based Food Products.

An area of vital interest is village industry scale processing and home use of soybeans. However, one of the serious drawbacks regarding home or village industry utilization of soybeans is the long cooking time to achieve acceptable tenderness. Whole soybeans, prepared by accepted cooking methods, require soaking periods of 6-8 hours at about room temperature followed by a cooking time of at least two hours. Long cooking times to achieve satisfactory tenderness, are wasteful of fuel and make village industry and home use of soybeans difficult and not attractive. Thus, there is considerable interest in developing some concepts for rapid preparation of certain soy based products that would be entirely suitable for village level use. These concepts are being investigated by two graduate students working on Master's degree programs. One of the students will complete the thesis during the summer of 1975 while the other student's program will require an additional one year. Work on concepts indicate that products such as weaning or breakfast foods can be prepared from dry, raw soybeans with about 30-40 minutes total cooking. Also fried soy and cereal patties which, from a calculated basis, appear to approach meat as regards protein content and quality can be prepared in about the same time. A concept for preparation of soy beverage at the village level is under development and the results to date are preliminary but encouraging. Some of these concepts require that the beans be broken and/or ground either before or after cooking or at both times. Thus, a small capacity mill of about laboratory or pilot plant size, which would be suitable and reasonable in cost, is urgently needed Such a mill should be suitable for grinding or breaking dry soybeans or grinding blanched beans into a slurry.

The major journals of the food processing field, including the last six years of the Food Science and Technology abstracts were searched for possible equipment suppliers. The agricultural machinery section of the University of Illinois Agriculture Library contained no information that was useful. A number of manufacturers were found in the Institute of Food Technologists World Directory and Guide, the Thomas Register, Canner and Packer and the Agricultural Engineers' Yearbook. Letters were written to 85 of the manufacturers requesting literature and information on their mills and grinders. Sixty replies were received but only twenty-one manufacturers appeared to have equipment that offered some possibility for use. Most of the equipment was far too large or costly to be suitable for the purposes outlined. The initial letter of inquiry indicated that the chief interest wa in small laboratory or pilot type mills that would cost $2,500.00 or less.

No canvass was made of manufacturers outside the U.S. Perhaps suitable mills manufactured in other countries can be located. However, a previous survey, under a USAID contract in India, indicated that equipment made in the U.S. was generally more versatile and of lower price than similar equipment manufactured in other countries.

The list of manufacturers offering electric powered equipment that might have some utilization for the project are as follows:

1. The United Company - a cream corn Macerator, reconditioned-$2,695.00 (2 HP).
2. Division of Mikropul (S. S. Filter Corp) - Bantam Mikro-Pulverizer will grind dry or slurries. (1 hp) Hammermill. (no price)
3. Williams Patent Crusher & Pulverizer Co., Inc. - Lab hammer. (3/4 hp) $2,650.00 in stainless steel, perhaps too small to be of value.
4. Schutz - O'Neill Co. - 10 hp mill ($4,620). Less main motor. Appears to be too large unless used as a community mill.
5. Rietz Manufacturing Co., - 3 hp Hammermill. $4,870.00 suitable but quite expensive.
6. The Fitzpatrick Co. - 3 hp, $2,921. Might be suitable, needs further investigation.
7. Sturtevant Mill Co. - 5 hp impact mill, $5,500.
8. Federal Machinery & Equipment Co. - 5 hp Fitzmill, used $2,250.00 to $3,750.00.
9. Sprout - Waldron - Segmental plate mill. (5 hp) ($5,608), $2,906.00 Ni-Hard metal up to $4,500.00 for stainless steel.
10. The Bauer Bros. Co. - Single Disc mill (5 hp) ($5,608) $6,790.00 in stainless steel, variety of discs.
11. Urschel Laboratories - 5 hp Comitrol mill, Model 3600-screwfed-$4,000.00.
12. Franklin Miller, Inc. - Wet or dry grinding - iron & cast iron construction, $2,860.00

13. Decker Mfg. Co. - Hammermill, 2 hp, under $1,000, reported to be suitable for wet or dry grinding.
14. Alpine American Corp. - lab size pin mill. $4,600.00.
15. Mix-mill, Inc., 5 hp hammermill, no price.
16. Seedburo Equipment Co. - Small lab mills (p. 13, 43) from 1/4 hp to 3 hp. Viking Hammermill 1 or 2 hp units - no price quotation but possibly under $1,000.00
17. Union Standard Equipment Co. - rebuilt used hammermills, disc attrition mills, porcupine blade mills, as low as 1 1/2 hp - $850.00 - $1,550.00 for lab size.
18. Loeb Equipment Supply Co. - a 1 hp used hammermill by Fitzpatrick, $1,250.
19. Berkel Incorporated - meat grinders only - from $1,075 to $1,500.
20. Pulva Corp., hammermills, 3/4 hp, only for moist below 1% for soybeans, no price.
21. Stensrud Agri-Systems - 5 hp, $1,760 no literature sent.

Examination of the equipment offerings indicate that the cost of a small laboratory or pilot mill is generally above $2,500.00. Several companies offered reconditioned used equipment but condition of such equipment is often questionable and supply is unpredictable and very limited. Some of the larger mills listed might offer the possibility of being used as a community type mill.

One mill, offered by the Decker Mfg. Co. (Number 13 on the list), may have possibilities. This mill will be examined and if it appears promising, a unit will be purchased and thoroughly evaluated.

A survey will also be made to determine if suitable hand powered mills are available. It may be necessary to develop certain specific types of equipment for village level processing. If such an approach is followed and equipment is developed, effort will be made to prepare plans or prints which would be suitable for fabrication in LDC's.

SUMMARY:

The concepts for preparing highly nutritious whole soybean based products that can be prepared in 30-40 minutes are being developed and appear to be very promising. These concepts require that the whole soybean be broken or ground either before or after cooking or both. Thus, small size or pilot plant type mills are needed and a list of companies who could supply such equipment was developed. Only a few electric powered mills are available that appear suitable and are $2,500.00 or below in cost. These mills will be investigated and a survey of handpowered mills will also be made. It may be necessary to develop certain specific types of milling equipment.

Part V. Drum Dried Corn - Soybean Weaning or Breakfast Food Samples

A number of drum dried samples of various combinations of cereals and whole soybeans have been prepared in the laboratory. The samples have received good acceptability ratings and rat feeding studies generally indicated excellent nutritive properties. However, much information is needed regarding methods of preparation. For example, the amount of hull and fibrous tissue that is included in the product appears to be of very significant importance when soybeans are

DRUM DRIED CORN - SOYBEAN SAMPLES A Thru E.

The corn used in the samples A, B & D was prepared as follows:

Clean 5 Lb. yellow dent corn (from Savoy Grain Elevator)

to remove foreign material

↓

Corn was passed thru break rolls of small pilot

flour mill set at 0.028" spacing between rolls.

↓

Sift

↓

1st Mill — 22W / 32W / PAN — 22W portion passed thru break rolls set at 0.004" spacing

↓

Sift

↓

2nd Mill — 22W / 32W / PAN

↓

32 W portions from 1st & 2nd milling passed thru reduction rolls set at 0.002" spacing

↓

Sift

↓

3rd Mill — 22W / 32W / PAN

22W portions appear to contain mainly skin & germ - not used in preparing samples.

combined with most cereals. The amount of fiber in the product can certainly influence acceptability as well as nutritional considerations, especially with babies or small children. Thus, the following study was undertaken to evaluate the effect of the amount of corn fiber or hull which was included in several soybean - yellow dent corn mixtures. In addition, the effect of pre-gelatinization of the starch in the corn was studied. The study is outlined on the previous page.

Corn for Sample Mixes -

Sample	Description of Preparation of Corn
A	Collected in Pan from all three millings.
B	Collected on 32W screen in 3rd milling.
C	Whole corn milled to a flour in Mikropul hammer mill.
D	Same as A
E	Same as C

The procedure used for making samples A, B, and C was as follows:

1. Start with Wayne 1974, field dried, cleaned, whole soybeans.
2. Measure about 4.5 liters of water for each 1 Kg of soybeans used. Bring to a boil and then add the soybeans.
3. Boil gently for 30 minutes.
4. Drain and weigh.
5. Add dry corn product equal to the weight of dry soybeans used in step 2.
6. Mix the corn with the soybeans. Grind the soybeans and corn together to a smooth slurry using the Rietzmill equipped with a 3/32" screen. During grinding, add about 5.8 liters of water for each 1 Kg of soybeans used in step 2.
7. Dry the slurry on a double drum dryer to below 4% moisture, using a 0.01" spacing between the rolls and a steam pressure of 40 PSIG.
8. Package in plastic bags.

Sample D and E were prepared similarly but with one additional step: The slurry was cooked for 10 minutes to achieve starch gelatinization after grinding (6), but before the roller drying (7).

TABLE XV. Analyses of Samples

Sample	% Moisture *	% Protein **	% Fiber ***
A	2.0	23.2	5.64
B	2.0	24.4	5.53
C	2.1	23.8	5.33
D	2.5		5.74
E	2.2		5.78

* Dried in vacuum oven.
** Powder was roller dried but not vacuum oven dried.
*** Analyses made by Dr. F. C. Hinds, Department of Animal Science, University of Illinois, using procedure "Handbook Fiber Analyses." Goering and Van Soest, 1970. Agr. Handbook 379 - ARS - USDA.

The water uptake capacities of the five samples were measured in order to determine the quantity of water that would be taken up by a unit weight of sample and held without weeping or drainage of free water. (Table XVI)

TABLE XVI.

Sample	Water Uptake Capacity ml H_2O/gram solids
A	4.51
B	4.30
C	3.79
D	4.26
E	3.85

An amount of water in excess of the water uptake capacity was used for rehydration for organoleptic evaluation. 38 ml of tap H_2O were added to 6.7g of each sample. Samples C and E developed a wet appearance and tended to weep more than did the other samples. (Table XVII)

An organoleptic evaluation was conducted and the products were rated on a 9 point hedonic scale with 9 being rated as excellent, 5 just acceptable and 1 very poor. A high rating for off-flavor indicates absence of off-flavor in the product. Samples were rated for color, texture, consistency, flavor and off-flavor on a hedonic scale. The panel consisted of 12 graduate students and staff. The average ratings are given below in Table XVII.

Table XVII

Average Organoleptic Scores

Sample	Color	Texture	Consistency	Flavor	Off-Flavor
A	7.9	6.5	5.6	5.2	6.2
B	7.0	6.2	6.3	5.5	7.2
C	6.7	5.6	6.2	5.4	6.5
D	7.6	6.4	6.4	6.7	7.7
E	6.2	5.7	5.8	6.6	7.0

A variance analysis was conducted to determine the significance of variations in the sample ratings. (Table XVIII)

Table XVIII

SIGNIFICANCE OF VARIATION

Sample Characteristic	Due to Panelist		Due to Sample	
		1% Level		1% Level
Color		Yes		Yes
Texture		Yes		No
Consistency		Yes		No
Flavor		Yes		Yes
Off-Flavor		Yes		No

Table XV presents data on percent protein, moisture and fiber content. The percent protein in the products indicate some variations, but it is impossible to determine if these differences are due to milling variations or normal sampling error. In any event, the protein differences do not appear to be of real significance.

Of most interest, Table XV, are the data on percent fiber content. Samples C and E were prepared using a corn component that was prepared by milling the entire whole corn kernel into a flour. It was believed that this sample would exhibit the highest hull or fiber content. However, percent fiber data in Table XV indicates that no real difference in fiber exists amongst the samples. Samples C and E should be essentially the same as regards fiber. However, E is somewhat higher in fiber than C but all samples seem to be in the same general range. An interesting question arises as to why the whole ground corn was not noticeably higher in fiber than the milled and screened samples A and B. This may be due to the following:

(1) Total fiber content of corn is listed from about 2.2 to 2.5% in various published composition tables. Thus, the fiber contributed from the corn in the product is very much lower than that contributed from the whole soybean.

(2) Milled samples A and B were noticeably free from the germ and attached tissues. Perhaps the percent fiber was increased in these samples due to exclusion of germ and attached tissue. This would also result in increased starch content on a percentage basis. Water uptake data bears this out as well as the smoother texture in the sample which resulted from the gelatinized starch.

The water uptake data, Table XVI, indicate that the products containing whole ground corn did not take up as much water as the other products. Products which were precooked prior to drum drying did not take up more moisture as compared to similar samples in which the starch was not pre-gelatinized. This also shows that the samples containing whole ground corn had the lowest water uptake property.

Table XVII presents the average organoleptic ratings and Table XVIII shows the significance of variation due to panelist and sample. Examination of Table XVII indicates that the color of the samples containing the whole corn kernel were inferior to samples in which most of the germ and some hull were removed. Texture values of samples containing the ground whole kernel were always inferior to the other products. Some variation was noted in consistency, Table XVII, but no explanation was apparent. Flavor and off-flavor scores were invariably superior when the products were precooked or gelatinized.

Examination of Table XVIII shows that a high significance of variation was found amongst the panelists. This seemed to be due in part, to strong personal preferences of the various panelists that included individuals from different areas of the world.

SUMMARY. Part V

In general the conclusions reached from these data indicate that:

(1) pre-gelatinization generally improved flavor but slightly reduced acceptability.

(2) Samples containing whole ground corn were generally inferior to the other products containing the corn fractions. This is most interesting and unexpected because texture acceptability did not relate to fiber content in the final samples.

However, this study clearly indicates that further work is needed to determine the best milling practice for corn that is used in combination with whole soybeans. Apparently certain fractions of the hull and perhaps the germ of corn do not tenderize and break down during milling, cooking and drying. This results in a texture that tends to contain many particles which gives a highly objectionable organoleptic texture characteristic. Similar studies should be made on essentially all of the different cereal-soybean drum-dried weaning foods.

Dissemination of Information

Visitors.

In excess of 160 people visited the Food Processing Laboratory during the contract year. Approximately three-fourths of these visitors were from foreign countries. At least 120 man-hours were spent by the INTSOY Food Science Faculty Team in discussions and demonstrations with foreign visitors. We estimate that at least triple that amount of time was spent by faculty and technical assistants preparing food product samples, setting up and removing demonstrations and preparing samples for shipment to various foreign visitors.

During the year, many foreign requests for information were received by mail. More than 50 letters were written in response to these requests and that an average of 3 hours time was spent by the team member in replying to letter requests. In addition, at least an equal number of requests were answered by sending out literature and no records of this were kept.

Travel.

One team member spent five weeks visiting four African countries. The countries visited were: Ethiopia, Kenya, Nigeria and Ghana. Trip reports on these visits were submitted earlier. The purposes of this trip were:

1. To discuss the progress of the East African Soybean Workshop with the workshop committee in Ethiopia and to make necessary plans and changes in the program, budget or administration of the workshop.
2. To stimulate interest in attending the East African Soybean Workshop in the countries visited.
3. To visit scientists and others in Africa who were interested in soybean foods.
4. To demonstrate some possible uses of whole soybean foods where facilities permit.
5. To gather general information on African diet and nutrition which would assist in finding means of introducing soybeans into their diet.

Accomplishments included the following:

1. Presentation of several seminars and participation in many discussions with African scientists and government officials on the use of whole soybean foods in African diets.
2. A visit to a small-scale "Faffa" plant in Addis Ababa, Ethiopia. The plant, which was really a pilot plant, produced about 300 tons of Faffa per month. This production was substantially greater than the output of a much more expensive "Incaparina" plant which was visited last year in Guatemala.
3. Discussion of plans and progress for the East African Soybean Workshop with the local committee.
4. Discussion with scientists in Kenya of plans to grow soybeans nation-wide.
5. Contact with members of IITA and discussion of possible cooperation with them.
6. Discussion of the Industrial Introduction "Soy-Ogi" into the Nigerian market. Ogi is a staple, traditional, fermented, ground-maize food. "Soy-Ogi" is a fermented, soy-maize flour. Both infant and adult formulations were being made on a pilot plant scale by the Federal Institute of Industrial Research.
7. Discussion with numerous government, University and industrial persons of the possibilities for production and utilization of soybeans in Ghana.

One team member was on the committee for the East African Soybean Conference held in Ethiopia. About three weeks time was spent in assisting with preparations for, and in the operation of, the conference. A review paper titled "Simple Processing of Whole Soybeans" was presented.

Publications.

Three publications resulted in whole or in part from work carried out under the contract. They are as follows:

1. A review of work carried out at the University of Illinois by L. K. Ferrier titled "Simple Processing of Whole Soybeans" published in Soybean Production, Protection, and Utilization -- Proceedings of a conference for scientists of Africa, the Middle East and South Asia. INTSOY Series 6, D. K. Whigham, Editor, March 1975.

2. A paper containing part of the nutritional information gained from PER studies of soybean cereals by Perkins, E. G., Ferrier, L. K., Wei, L. S., Steinberg, M. P. and Nelson, A. I. The title is "Nutritional and Chemical Studies of Foods Made from Whole Soybeans and Cereals," to be presented at Paris, May 1975.

3. A paper resulting from investigations into the use of bicarbonates for canning soybeans, by Ferrier, L. K., and Rosborough, D. J., "Effect of Bicarbonate Processing on Texture of Canned Soybeans," to be presented at the Annual Meeting of the Institute of Food Technologists, June 1975.

A P P E N D I X VII

TRAVEL OF CONTRACT STAFF

Trip reports of staff on contract travel are submitted to AID/W at the completion of each trip and are on file with the project monitor. Exerpts from trip reports written during the report year are reproduced below.

I. NAME: Whigham, D. K.

DEPARTMENT: Agronomy

COUNTRY: Sudan

DATES: April 2-7, 1974

PURPOSE:

1. To discuss and evaluate the results of the 1973 INTSOY trial tested at the Gezira Research Station.
2. To inform research personnel about the 1974 INTSOY variety evaluation experiment which is coming to the Sudan via FAO.
3. To design variety and cultural management experiments for testing the adaptability of soybeans in Sudan's many environments.
4. To discuss the potential of soybean production and utilization in Sudan with Ministry, Agricultural Research Corporation, FAO, and U. S. Embassy Officials.

RESULTS/ACCOMPLISHMENTS:

1. Discussed the results from the 1973 INTSOY trial which was tested at Wad Medani. The top yielding variety was Williams (1.7T/ha) followed by Semmes, Bragg, Davis, Improved Pelican and Hampton 266A (1.3T/ha).
2. Informed the research staff about the 1974 INTSOY experiment which is being distributed through FAO. Changes made for the 1974 trial were explained.
3. Established guidelines for future soybean research in

the Sudan. Seed harvested from the 1973 trial will be utilized for variety and cultural trials at five research stations.

4. Discussed soybean production and utilization potential in the Sudan with agriculture officials. In the North and East sections of the country soybeans must be irrigated. However, in the South and possibly the West, they will not need to be irrigated.

5. Observed the Gezira Irrigation Scheme and learned how productive the soils along the Nile River are when irrigated properly.

6. Filmed a ten minute videotape on "Soybean Research in the Sudan" for the U. S. Information Service.

7. Observed the location of the 75,000 acre Big Valley Farm where soybeans are being tested for inclusion in a crop rotation.

8. Discussed FAO activities in the Sudan with the Country Representative.

II. NAME: Whigham, D. K.

DEPARTMENT: Agronomy

COUNTRY: Ethiopia

DATES: April 7-12, 1974

PURPOSE:

1. To obtain permission to hold a regional soybean workshop in Ethiopia during the fall of 1974.

2. To identify a local committee to make local arrangements for the meeting.

3. To establish a date for the workshop which is acceptable to all parties involved.

4. To discuss soybean research in 1974 in Ethiopia.

5. To discuss the proposed AID/Ethiopia supported "Pulse Project."

RESULTS/ACCOMPLISHMENTS:

1. Obtained approval from the AID Mission to proceed with plans for a soybean conference.

2. Local arrangements for the conference will be made by the Institute of Agriculture Research (IAR). Dr. Dagnatchew of IAR will serve as chairman of the local committee.

3. The Ethiopian Nutrition Institute (ENI) will cooperate with IAR in planning for the conference.

4. Dates for the conference will be October 14-18, 1974.

5. The theme of the conference will be, "Soybean: production, protection and utilization". Interested researchers from Africa, the Near East and South Asia will be invited.

6. Participated in the seminar on "Protein Nutrition" at ENI.

7. Toured the ENI pilot plant where FAFFA is prepared. FAFFA is a fortified flour which contains 18% soybean flour.

III. NAME: Ferrier, Leslie K.

DEPARTMENT: Food Science

COUNTRY: Ethiopia

DATES: July 8-13, 1974

PURPOSE:

1. To discuss the progress of the East African Soybean Workshop with the workshop committee in Ethiopia and make necessary plans and changes in the program, budget or administration of the workshop.

2. To visit scientists and others in Ethiopia who are interested in soybean foods.

3. To demonstrate some possible uses of whole soybean foods where facilities permit.

4. To gather general information on Ethiopian diets and nutrition which would assist in finding means of introducing soybeans into the diet.

RESULTS/ACCOMPLISHMENTS:

1. Discussed Ethiopian dietary habits and nutrition with members of ENI and USAID/Ethiopia. The great majority of Ethiopians produce and consume their own food; this diet is very simple and introduction of new foods will be difficult. (See "Other Remarks.")

2. Discussed potential small industry, village and home uses of soybeans with members of ENI staff. Discussed laboratory aspects of soybean composition analysis and processing with members of ENI staff. Toured "Faffa" production plant (see Attachment C).

3. Presented a seminar at ENI on "Simple methods of processing whole soybeans for use as human food." Conducted a demonstration of and an experiment on methods of preparing of whole soybeans for food.

4. Discussed progress of the East African Soybean Workshop with the workshop committee in Ethiopia and made appropriate changes in plans and budget for the workshop.

5. Visited soybean trials at Debre Zeit and discussed some potential uses of soybeans with Dr. Don Schmidt.

IV. NAME: Ferrier, Leslie K.

DEPARTMENT: Food Science

COUNTRY: Kenya

DATES: July 14-23, 1974

PURPOSE:

1. To stimulate interest in attending the East African Soybean Workshop.

2. To visit scientists and others in Kenya who are interested in soybean foods.

3. To demonstrate some possible uses of whole soybean foods where facilities permit.

4. To gather general information on Kenyan diets and nutrition which would assist in finding means of introducing soybeans into the diet.

RESULTS/ACCOMPLISHMENTS:

1. Conducted discussions and a seminar with a number of people who are in the Nairobi area and who are interested in soybean production and utilization in Kenya. These activities should lead to increased awareness of additional possibilities for the use of soybeans in East Africa. They may also lead to increased attendance at the East African Soybean Workshop.

2. Discussed possible ways for utilizing soybeans with members of the Institute for Development Studies, University of Nairobi. This should lead to improved awareness and more definite planning on the utilization end of their plan for national production of soybeans.

V. NAME: Ferrier, Leslie K.

DEPARTMENT: Food Science

COUNTRY: Nigeria

DATES: July 24-29, 1974

PURPOSE:

1. To stimulate interest in attending the East African Soybean Workshop.

2. To visit scientists and others in Nigeria who are interested in soybean foods.

3. To demonstrate some possible uses of whole soybean foods where facilities permit.

4. To gather general information on Nigerian diets and nutrition which would assist in finding means of introducing soybeans into the diet.

RESULTS/ACCOMPLISHMENTS

1. Discussed foods in Nigerian diets and possibilities for incorporating soybeans in Nigerian foods with persons contacted at Federal Institute of Industrial Research, Ford Foundation and IITA. (See Itinerary.)

2. Presented seminar on soybean foods at IITA.

VI. NAME: Ferrier, Leslie K.

DEPARTMENT: Food Science

COUNTRY: Ghana

DATES: July 29-August 7, 1974

PURPOSE:

1. To stimulate interest in attending the East African Soybean Workshop.

2. To visit scientists and others in Ghana who are interested in soybean foods.

3. To demonstrate some possible uses of whole soybean foods where facilities permit.

4. To gather general information on Ghanian diets and nutrition which would assist in finding means of introducing soybeans into the diet.

RESULTS/ACCOMPLISHMENTS

1. Discussed the University of Illinois methods for utilizing soybeans directly as human foods, and the possibilities of growing soybeans in Ghana and incorporating soybeans directly or indirectly (via poultry) in Ghanaian diets with people from the organizations listed under Organizations/Persons Contacted.

2. Discussed the practical possibility of future production of soybean oil in Ghana by using expellers and solvent extractors with members of the Crystal Oil Mills, Ltd, and the Tema Food Complex Corporation. There was a strong desire to test soybeans for oil production on the part of both these organizations in order to see if the use of soybeans grown in Ghana as a source of oil was economically sound.

3. Presented two seminars and led discussions on the present and future development of soybeans in Ghana at the University of Ghana (Legon). The seminars and the discussions centered on the possible direct and indirect uses of soybeans in Ghana both for animal and human feed and food, and for export. Initial reactions of the participants varied from enthusiasm and determination to complete skepticism about the acceptability of soybeans directly in the diet. Nevertheless, by the end of each session, most of the participants seemed to realize: (a) that the soybean has considerable potential for the future, (b) that the members of the College of Agriculture were going to push for nation-wide production in a few years, and (c) that they were being presented with some lead time for the development of plans, methods and foods which would be suitable for use in Ghana. It was interesting to note that the strongest skepticism came from the Home Science extension workers. Pessimism seemed to be directly proportional to the closeness of the workers, to Ghanaian dietary habits and lack of experimental experience with soybeans.

VII. NAMES: Godfrey, George L. and Bouseman, John K.

DEPARTMENT: Agricultural Entomology

COUNTRY: Mexico

DATES August 6-14, 1974

PURPOSE:

1. To expand a survey of insects associated with soybeans in Mexico and initiate a survey in western Texas.

2. To meet with Mexican entomologists and discuss plans to jointly publish the results of the cooperative survey of soybean insects in Mexico when it is completed.

3. To inform Mexican entomologists involved in soybean research of INTSOY and determine their general interest in participating in future cooperative research projects if and when assistance by INTSOY personnel is needed.

RESEARCH/ACCOMPLISHMENTS:

1. Succeeded in obtaining ten quantitative insect samples from previously unsurveyed soybean producing regions in Mexico, specifically the states of Chihuahua and Tamaulipas. The Mexican entomologists associated with the Instituto Nacional de Investigaciones Agricolas (INIA) that we met are very interested in assisting with a complete survey. One senior entomologist has agreed to continue working closely with this project and to publish the results under joint authorship. Three quantitative soybean insect samples in western Texas were taken as the initial steps to implement a survey in that area.

2. Discussed the major world soybean insect problems with the entomologists in Mexico and brought to their attention the major problems that INTSOY entomologists forsee in the future due to indiscriminate spraying of insecticides, especially in the trópics and subtropics.

3. Discussed INTSOY research programs with persons that we met. Most individuals were aware of the existence of INTSOY but did not realize its magnitude. Nearly every individual was interested in receiving some form of assistance through INTSOY.

4. Discussed the possibility of the Mexican soybean entomologists contributing to the World Soybean Research Conference being planned by the University of Illinois for August 3-8, 1975. One researcher agreed to participate.

VIII. NAME: Goodman, Robert M.

DEPARTMENT: Plant Pathology

COUNTRY: Nigeria

DATES: October 19-27, 1974

PURPOSE:

1. To visit centers of agricultural research where soybeans and other legumes are studied and to become acquainted with soybean research programs in Nigiera.

2. To learn about the conditions prevailing in the agricultural areas of Nigeria with special reference to the compatibility of soybeans and these conditions.

3. To become acquainted with plant pathologists in Nigeria who are interested in soybean and general legume pathology.

4. To examine soybean and other legume plantings under a variety of conditions for symptoms of virus diseases.

5. To discuss with Nigerian legume virus research workers possibilities for cooperative work.

6. To work toward improved relationships and communication between the staff of the International Institute of Tropical Agriculture and INTSOY.

7. To learn of efforts, if any, to introduce soybeans for use as human food using traditional Nigerian ways of cooking.

8. To encourage cooperation between soybean workers in Government and University institutes and INTSOY.

9. To present a seminar on soybean virus diseases of worldwide importance at IITA.

ACCOMPLISHMENTS: (Itemized list of persons contacted is in Attachment B).

1. I visited the International Institute of Tropical Agriculture, the University of Ife Institute for Agricultural Research and Training, the Federal Department of Agricultural Research at the Moor Plantation, the Institute of Agricultural Research Station (Ahmadu Bello University) at Mokwa, the Institute of Agricultural Research (Ahmadu Bello University) at Samaru, and the Ahmadu Bello University Hospital at Zaria. Important food legume research, including studies on soybeans, is being done at IITA, and at the various units of the Ahmadu Bello University. At IITA soybeans are planted in April and in August. The second planting is essentially disease free, but must be sprayed occasionally with insecticides to control grasshoppers and other foilage-feeding insects. In the first season virus-like diseases are rather severe; the etiology of these has not been established.

At Mokwa and Samaru, soybeans are planted in late June for harvest in October. Some varieties had matured by the time of my visit, others were beginning to senesce. Generally, stands were good and the crop was essentially free of virus disease. At Mokwa there was a severe pod disease affecting 20 - 30% of the pods. The disease appears to beanthracnose. Isolations from materials I collected at Mokwa have been made by Dr. R. J. Williams, IITA, and Duncan McDonald, IAR, Samaru. Flowering occurred during an especially wet time this season, and as

the pods developed many were affected by the disease. At Samaru, soybeans were free of significant disease.

Breeding programs are under way at IITA and at Mokwa. Both programs favor relatively early maturing selections (less than 100 days) and short plants, with dense pod set. Mokwa and IITA breeders exchange breeding lines for yield and agronomic trials at both locations.

With the exception of the virologist at the University of Ife, Moor Plantation, Ibadan, I was not impressed with the soybean research being done at the Moor Plantation by either University of Ife or FDAR personnel. Their plots were very uneven and poorly attended, and they seemed to have only a superficial interest in soybean research.

2. Nigeria is blessed with a number of competent plant pathologists working in the food legume area. In addition to IITA personnel, there is a plant virologist at both the University of Ife Institute of Agricultural Research and Training, and at the Federal Department of Agricultural Research, Ibadan. There are also a virologist, two nematologists, and two general plant pathologists at Ahmadu Bello University, Samaru, and a nematologist at the University of Ife, Ile-Ife.

Dr. S. A. Shoyinka has been isolating viruses from soybeans and cowpeas and has facilities available for partial purification of viruses. He is eager to have cooperation in preparation of antiserum, which will require more rigorous purification of the viruses than facilities available in Nigeria permit. Dr. R. J. Williams, IITA, is also willing to cooperate with Dr. Shoyinka and INTSOY personnel. Dr. S. Subbarayudu, IAR, Samaru, is also setting out to survey virus diseases of important crop plants in northern Nigeria, but his responsibilities include many other crops aside from soybeans. Tentative discussions with Shoyinka

and Williams were held to explore areas of mutual interest and cooperation.

3. I discussed with Dr. H. Albrecht, Dr. K. O. Rachie, and Dr. R. J. Williams, relationships between IITA and INTSOY in an attempt to clarify what IITA personnel see as their prerogatives and interests insofar as soybean research and development for the tropics are concerned.

4. I met Dr. Theodore Kay, biochemist at the Ahmadu Bello University Hospital, Zaria, who has devoted a considerable portion of his time and personal finances to developing ways of using soybeans in traditional Nigerian cookery and to popularizing the use of soybeans at the peasant village level. Dr. Kay prepared and served me a meal of Nigerian food and gave me copies of his project report and a typescript of a publication on the use of soybeans in Nigerian diets.

5. In a seminar delivered at IITA, and in discussions with scientists and administrators of the FDAR, University of Ife and Ahmadu Bello University, I described the resources that INTSOY could contribute to soybean development in Nigeria and indicated our eagerness to establish direct informal or occasional relationships between INTSOY and agencies in Nigeria working on soybeans. I also outlined in some detail the ways in which formal assistance for training and research could be given when asked to do so by the Director of the Institute of Agricultural Research, Ahmadu Bello University, Samaru.

IX. NAME: Goodman, Robert M.

DEPARTMENT: Plant Pathology

COUNTRY: Ghana

DATES: October 27-November 2, 1974

PURPOSE:

1. To visit centers of agricultural research and become acquainted with soybean research programs in Ghana.

2. To learn about the conditions prevailing in areas of Ghana where soybeans can be grown.

3. To become acquainted with plant pathologists in Ghana who are interested in soybean and general legume pathology.

4. To examine soybeans in Ghana for symptoms of diseases, with special emphasis on virus diseases.

5. To discuss with research and government personnel the possibilities for cooperative work on soybean development and soybean pathology in Ghana.

6. To encourage Ghanaian soybean research workers to avail themselves of assistance from USAID and INTSOY for their soybean research program.

7. To present a seminar on the INTSOY program and soybean diseases for the students and staff of the Faculty of Agriculture, University of Ghana, Legon.

ACCOMPLISHMENTS AND GENERAL OBSERVATIONS (Itemized list of persons contacted is in Attachment B)

1. I visited the Crops Sciences Department, University of Ghana at Legon, the Faculty of Agriculture, University of Science and Technology At Kumasi, the Crops Research Station at Kwadoso, the Grains Development Board at Kumasi, and the USAID Mission to Ghana at Accra. I also attended the National Agricultural Fair held at the Accra Trade Fair Site.

There is a major government campaign on in Ghana called "Operation Feed Yourself," to promote agricultural production in the country.

The interest in soybeans in Ghana is one facet of this campaign. Dean Acquaye, of the Faculty of Agriculture at Legon and others I talked to said that the primary interest in soybeans for Ghana is as a source of high protein meal for animal production. No effort is planned to popularize soybeans as direct human food, although the Dean felt that if soybeans were grown extensively in the country, they would find their way into human food soon. As a result of the government campaign, the Grains Development Board and the research institutes feel some pressure to do research on soybeans. The Government wants soybean production now, whereas the research workers are rather cautious. No large acreages of soybeans are yet grown in Ghana.

In all areas of Ghana that I visited, there are two growing seasons, the first from April to July during the major rains, and the second from August to late October or November, during the minor rains. In the north of Ghana (Tamale) there is one season (June to October) as in northern Nigeria. It is in the region north of Kumasi, which is largely savannah grasslands, where maize and ground nuts are now grown and where soybeans would be particularly suited.

2. The soybean plantings I viewed were generally good. Stands were reasonable in most cases, although they do have the problem with seed germination at high soil temperature noted in other tropical areas. The soybeans I viewed were generally healthy and those at Kpong, Kumasi, and Kwadoso were showing especially good vegetative growth. The most severe disease problem noted was purple stain of the beans. Harvesting soybeans during late July or August in southern and central areas of Ghana presents a serious problem if the short, dry season at that time of year does not coincide with the time when the beans

mature. In this year's crop, purple stain affected up to 50% of the seeds from fields in both Kwadoso and Legon.

3. At Kumasi and Kwadoso, I saw plantings of Davis soybeans showing a moderately severe rugose condition in the foliage that resembled certain symptoms of soybean mosaic virus, but there were no mosaic symptoms. Where it occurred, nearly all the plants were affected. But, at CRI, Kwadoso, two trials were planted at the same time in adjacent areas of the same field from the same seed source, and only part of one of the trials was affected. I surmised that the effect may be caused by residual herbicide from previous years. At Kumasi one of the field officers when questioned found that the affected area of the field had, in fact, been used for an herbicide trial in 1973. I do not believe that the symptoms seen represent a severe outbreak of soybean mosaic virus infection.

4. During my visit to the Kpong Research Station where irrigation facilities are available, Dr. J. Aryeetey, research officer, suggested that because of the seed quality problem during the major season, soybeans for seed should be grown in irrigated areas late in the second season. Harvesting would then be done in December when it is always dry. If methods were found to store seed safely until planting time the following April a good seed source would be assured.

5. I visited Dr. Paul Lamptey, plant pathologist in the Faculty of Agriculture, Legon. Dr. Lamptey is a plant virologist by training, who teaches general plant pathology to undergraduates and honors students at the University of Ghana. He is interested in legume virology, and has some studies under way on African cowpea mosaic virus which can infect soybeans. Dr. Lamptey is the only trained plant pathologist at the University of Ghana. The only other plant

pathologists are at the Crops Research Institute, Kwadoso, where there are two nematologists and a virologist, and those at the Cocoa Research Institute at Tafoe, most of whom are British. Any large-scale expansion of soybean production in Ghana will almost certainly require the services of a soybean pathologist who at least at first will have to come from outside Ghana.

6. I visited at some length with Dr. F. N. Ghartey, Jr., and Mr. S. K. Ankoma of the Grains Development Board, Mr. Hector Mercer-Quarshie, Dr. Victor Doku, Dean D. K. Acquaye, and Dr. G. F. Nsowah about the proposal that may be made by the Committee on Soybean Research in Ghana to USAID and INTSOY for assistance with the development of soybeans in Ghana. I impressed upon them that Mr. James Ford, USAID Chief Food and Agriculture Officer has budgeted several man months of INTSOY consultant time for the current fiscal year to help get their proposal implemented. I encouraged them to expedite the proposal and to send INTSOY a copy of the porposal that they submit to AID. This they would do.

7. I delivered a seminar to the honors students and academic staff of the Faculty of Agricultue at Legon, in which I discussed INTSOY in some detail and also illustrated several important soybean diseases caused by nematodes, fungi, and viruses. The question and discussion session following my seminar lasted over 30 minutes, indicating a high level of interest.

8. Agronomists I talked to in Ghana were generally agreed that Improved Pelican, CES 407, CES 486, Davis, and Jupiter (F62-3977) are the best varieties under Ghanaian conditions. Bossier has not performed as well as the above mentioned varieties in Ghana.

X. NAMES: Goodman, Robert M. and Irwin, Michael E.

DEPARTMENTS: Plant Pathology and Agricultural Entomology

COUNTRY: Puerto Rico

DATES: January 11-18, 1975 (Goodman) - January 11-22, 1974 (Irwin)

PURPOSE:

1. To assess the feasibility of using Puerto Rico as a testing ground for in-depth crop protection studies on soybeans grown in tropical and subtropical environments by:

a. Meeting entomologists and plant pathologists working in Puerto Rico and discussing their work and interests in order to assess potential cooperation in pest management and disease programs.

b. Visiting the various agricultural experiment stations and substations in Puerto Rico in order to assess laboratory, greenhouse, equipment items and field facilities, land availability and professional staff willingness for potential plant protection and pest management programs.

c. Assessing areas, preferably substations, where climatic and environmental conditions differ sufficiently to allow a wide degree of latitude in eventual pest management and crop protection programs.

2. To discuss in detail with Dr. E. Hamer Paschal II the INTSOY breeding program in Puerto Rico and needed cooperative work to assure adequate screening of candidate germplasm of virus and insect pest resistance, and to develop plans for evaluation of such resistance.

3. To collect samples of soybean viruses for purification at the University of Illinois at Urbana-Champaign, for eventual serological work in Puerto Rico.

4. To begin an intensive survey of soybean arthropods for inclusion in the INTSOY faunal survey at the University of Illinois at Urbana-Champaign.

5. To discuss with Dr. Julio Bird, Plant Virologist, University of Puerto Rico, Rio Piedras, joint research in soybean virology and whitefly transmission of such viruses.

6. To discuss the details with Dr. Pedro Meléndez and Dr. Victorio García of an experiment on field spread of soybean mosaic virus by aphid vectors.

RESULTS/ACCOMPLISHMENTS:

1. Puerto Rico was traversed, most entomologists and plant pathologists on the island were met and fruitful discussions were held concerning crop protection, pest management and availability of time, funds, and energies. All but one of the experimental substations were visited (discussions of facilities and willingness to cooperate are included in the discussion under Attachment A: Detailed Itinerary and Schedule of Activities).

2. A cooperative program to breed disease and insect pest resistance into soybeans adapted to tropical and subtropical environments was initiated by Dr. E. Hamer Paschal II, Dr. Robert M. Goodman, Dr. Pedro Meléndez, Dr. Victorio García, and Dr. Michael E. Irwin. This program will incorporate germplasm already screened for resistance to diseases and to insect defoliators--and possibly a line resistant to stink bugs--into lines agronomically suited for the tropics and subtropics.

3. Samples of several viruses attacking soybeans at the Isabela and Lajas substations were collected. These will be characterized, purified and used to produce antiserum for serological detection work in Puerto Rico and elsewhere.

4. Two collections of insects in soybean fields were made, one at the Isabela Substation and one at the Lajas Substation. Relatively few insects were obtained, principally because the fields were sprayed with insecticides on a weekly basis. Most notable was the almost total lack of parasites and predators.

5. We had an extensive and productive discussion with Dr. Julio Bird concerning viruses transmitted by whitefly vectors. Dr. Bird expressed a willingness to cooperate in areas of virology and vector transmission with the INTSOY virologist and entomologist.

6. An experiment on field spread of soybean mosaic virus by aphid vectors was discussed in detail. The experiment will be conducted in collaboration with Dr. Pedro Meléndez, Dr. Victorio García and Mr. Curt Nissly on a one-half-acre plot at the Isabela Substation.

XI. NAME: Whigham, D. K.

DEPARTMENT: Agronomy

COUNTRY: Taiwan

DATES: January 29 - February 3, 1975

PURPOSE:

1. To discuss cooperative activities between AVRDC and INTSOY in the area of breeding, pathology, entomology, and training.

2. To inform AVRDC about plans for an Asia Soybean Workshop in 1976 and to solicite their cooperation in conducting the meetings.

3. To discuss the results of past INTSOY variety trials and outline future cooperation.

4. To observe soybean research activities at the Taiwan Agricultural Research Institute and the National Chung-Hsing University.

5. To obtain permission from the U. S. Agricultural Attache to send materials to AVRDC via his office.

RESULTS/ACCOMPLISHMENTS:

1. Received permission from the Agricultural Attache of the American Embassy to send materials to AVRDC via his office.

2. Explained the soybean production training course to TARI staff who hope to send a participant.

3. Collected soybean research publications on management and soybean rust from TARI and the National Chung-Hsing University.

4. Informed AVRDC Directors about the proposed Asia Soybean Workshop and received their commitment to cooperate with INTSOY in developing a useful meeting.

5. Discussed the AVRDC soybean breeding program and requested their segregation lines for evaluating in Puerto Rico.

6. Investigated the current soybean rust research activities at AVRDC and discussed ways in which INTSOY and AVRDC may cooperate in future rust research.

7. Observed the major soybean production area (Kaohsiung District) of Taiwan and discussed variety development with the soybean breeders.

8. Discussed results from past INTSOY trials. Local variety Shih Shih produced the highest yields at the AVRDC location. Plans were discussed for testing five INTSOY trials in Taiwan during 1975.

9. Discussed the opportunities for cooperative training activities between INTSOY and AVRDC. Graduate degree thesis research and sabbatical arrangements may be made with AVRDC.

10. Presented a seminar "INTSOY and International Soybean Variety Evaluation" to 35 AVRDC staff members.

XII. NAME: Whigham, D. K.

DEPARTMENT: Agronomy

COUNTRY: Philippines

DATES: February 4-7, 1975

PURPOSE:

1. To discuss past results of INTSOY trials and plan future cooperation between INTSOY and the University of the Philippines at Los Banos (UPLB) and the Bureau of Plant Industry (BPI).

2. To develop a soybean evaluation trial jointly between INTSOY and the Southeast Asian Regional Center for Graduate Study and Research in Agriculture (SEARCA).

3. To discuss plans for the Asia Soybean Conference with interested scientists.

4. To become acquainted with the soybean research activities of the International Rice Research Institute (IRRI).

RESULTS/ACCOMPLISHMENTS

1. Discussed soybean yield results with Mr. Ballon and Mr. Legaspi at the Bureau of Plant Industry (BPI) in Los Banos. Locally developed varieties are popular with farmers. Clark-63 is the most promising introduced variety. BPI requested continued cooperation with INTSOY.

2. Was informed about the activities of the Southeast Asian

Regional Center for Graduate Study and Research in Agriculture (SEARCA) by Dr. Saguiguit. SEARCA has its headquarters on the University of the Philippines at Los Banos Campus and serves eight countries.

3. Organized a cooperative INTSOY/SEARCA soybean variety trial for evaluating early maturing material at nine locations in Southeast Asia. INTSOY will provide eight varieties, the inoculant, instructions, data collection material and analysis of the data. SEARCA will provide nine varieties, site visitation and close communication with the cooperators. All varieties are expected to mature in less than 100 days throughout the Region.

4. Discussed results of INTSOY trials and national trials with Dr. Lantican. The University of the Philippines at Los Banos College of Agriculture (UPLBCA) started a soybean breeding program in 1968. Several CES lines (developed at UPLBCA) are now being evaluated for release. UPLBCA desires continued cooperation with INTSOY in all phases of soybean research.

5. Visited the Food Science Department at UPLBCA and learned of their soybean milk product "Philsoy." The produce is being prepared for test marketing and possibly release as a commercial product. The product was quite acceptable even though a "grassy flavor" was evident.

6. Visited the International Rice Research Institute (IRRI) and learned where soybeans fit into the Multiple Cropping Program. Variety evaluation of soybeans has indicated that Multivar 80 (introduced from U.S.) and a local variety CES-16-203 were the highest yielding in a short season. IRRI does not plan to develop soybean varieties. However, locally developed and introduced

varieties will continue to be evaluated for adaptation to rotation with rice. The Multiple Cropping Section will soon begin variety evaluation of all crops which fit into a rice cropping system at 12 locations in six Southeast Asian countries.

XIII. NAME: Whigham, D. K.

DEPARTMENT: Agronomy

COUNTRY: Thailand

DATES: February 9-15, 1975

PURPOSE:

1. To discuss and evaluate the results of INTSOY trials with cooperators and to observe present INTSOY trials in the field.

2. To observe soybean production techniques used by their farmers.

3. To discuss the possibility of Thailand being the host country for an INTSOY sponsored Asia Soybean Conference in 1976.

4. To arrange shipment and distribution procedures for INTSOY trials requested by researchers in Thailand.

RESULTS/ACCOMPLISHMENTS:

1. Observed INTSOY trial and other soybean research at the Mae Jo Agricultural Experiment Station. Discussed results of previous soybean trials. The local variety, SJ-2, produced the highest yield.

2. Visited the Chiangmai University Faculty of Agriculture and discussed their soybean breeding and multiple cropping programs. Results of the wet season INTSOY trial were discussed. Williams variety was highest yielding.

3. The Faculty of Agriculture at Chiangmai University volunteered

to be a host for the Asia Soybean Conference if held at Chiangmai.

4. Observed INTSOY trial and other soybean research at the Chainat Rice Experiment Station. At this station soybean research is conducted during the dry season and rice research during the wet season. No-tillage planting techniques are used to seed soybeans after rice.

5. Observed INTSOY trial and related work at the National Corn and Sorghum Research Center at Farm Suwan. Varieties Improved Pelican (2430 Kg/ha) and Calland (2473 Kg/ha) have produced the highest yields in the wet and dry seasons, respectively.

6. Discussed results of past INTSOY trials with staff of the Northeast Agricultural Center (NEAC). Low yields are attributed to low fertility, low rainfall, insect damage and unadapted varieties. The variety Hardee produced a top yield of 619 Kg/ha during the wet season and Davis produced 1033 Kg/ha during the dry season.

7. Observed the INTSOY trial being tested at Khon Kaen University and discussed the influence of short days on the development of soybean varieties. Khon Kaen University is a regional center for the national program on soybean improvement.

8. Presented a seminar "Results of Soybean Variety Evaluation," to staff members of the NEAC and Khon Kaen University.

9. Arranged to ship all INTSOY trials to the Agricultural Office of the USAID Mission. Dr. Arwooth will collect and distribute the trials. Seven trials have been requested for testing in Thailand during 1975.

10. Dr. Arwooth suggested that the Asia Soybean Conference be held at Chiangmai in February, 1976.

11. Discussed the role of soybeans in new rubber plantations. Dr. Templeton is promoting the use of soybeans intercropped with rubber trees during early tree growth. An INTSOY trial was requested to evaluate varieties in southern Thailand.

12. Presented a seminar, "International Soybean Variety Evaluation," to scientists from Kasetsart University, Rubber Research Center and the Rockefeller Foundation.

13. Visited the Institute of Food Research and Produce Development and observed soybean products. Several soybean products from the Institute are being marketed throughout the country.

XIV. NAME: Goodman, Robert M. and Irwin, Michael E.

DEPARTMENTS: Plant Pathology and Agricultural Entomology

COUNTRY: Puerto Rico

DATES: February 22-March 2, 1975 (Goodman) - February 23-26, 1975 (Irwin)

PURPOSE:

1. Lay out and plant a one-half-acre field experiment at the Subestacion de Isabela.

2. Collect virus-infected tissue from soybean plantings at the Substacion de Isabela and perform serological tests to identify the viruses present.

3. Continue occasional collection of samples of tissue showing severe virus symptoms for identification and characterization at UIUC.

ACCOMPLISHMENTS:

1. A one-half-acre field was hand planted with Williams soybeans in a 4 x 4 plot design, each plot 30 feet square with sixteen 30-foot rows spaced two feet apart. Each plot is bordered by eight feet of

fallow, and the entire experiment is surrounded by three border rows of Williams soybeans. The land preparation was done through the cooperation of Luis Ortiz, Administrator Subestacion, and the planting by R. M. Goodman, M. E. Irwin, and E. H. Paschal with assistance of C. Nissly.

2. I made collections of severely infected soybean tissue from plants grown by Curt Nissly. These included samples from plants heavily infested with Cerotoma trifurcata and adjacent to a field of cowpeas that had earlier been found to be 100 percent infected with a severe strain of cowpea mosaic virus. Serological tests with antisera brought from UIUC were made in the laboratory of Drs. Pedro L. Melendez and Victorio Garcia. Results showed that plants with a wide range of symptoms, from mild yellow mottle to severe rogose mosaic, were infected with soybean mosaic virus. No evidence of cowpea mosaic, bean yellow mosaic, bean pod mottle, or tobacco ringspot viruses was found in these tissues. Several severely dwarfed plants with severely rugose leaves gave negative reactions in all tests.

3. Collections were made from soybeans planted at Subestacion de Isabela, as they have been on previous trips, for infectivity tests and characterization at UIUC. Tissue from diseased plants that gave no serological reaction was sampled, as was tissue from SMV-infected plants that had symptoms unusually severe for SMV alone.

XV. NAME: Irwin, Michael E.

DEPARTMENT: Agricultural Entomology

COUNTRY: Brazil

DATES: February 26 - March 18, 1975

PURPOSE:

1. To meet and converse with persons involved in the various soybean protection projects in southern Brazil, namely persons at EMBRAPA (Porto Alegre), IAPAR (Londrina), and FECOTRIGO (Cruz Alta).

2. To become acquainted with the techniques used by these people to initiate pest management programs, and to discuss with the people involved the problems and highlights of their pest management programs.

3. To observe first hand the defoliation by the velvetbean caterpillar and other Neotropical pests on soybeans and learn effectiveness by which such pests can be manipulated and how to assess their degree of damage to the crop.

4. To absorb techniques for pest management strategies in order to amplify and apply these in other parts of the world.

5. To collect soybean arthropods from soybeans grown in various areas of southern Brazil for incorporation into the international soybean arthropod collection.

6. To become acquainted with the insect resistant trials being conducted at IAPAR and EMBRAPA (Porto Alegre).

RESULTS AND ACCOMPLISHMENTS:

1. Professional entomologists and other crop protection personnel were contacted at IAPAR, EMBRAPA, USAID/Wisconsin team, FECOTRIGO and other areas (see Attachment B, Organizations and Persons contacted) and in-depth discussions of insect pests and management practices evolved.

2. During the course of the above mentioned discussions and while visiting field experiments and farmer fields, I was able to become thoroughly familiar with the techniques used in field manipulation and pest management of the various groups within southern Brazil.

3. The velvetbean caterpillar, Anticarsia gemmatalis, was encountered at almost every site where we observed soybeans. In areas where insecticides were not applied it was most abundant. In Parana the caterpillar was very destructive but was controlled by a funous, Nomuraea rileyi. In Rio Grande do Sul, the caterpillar was devastating, consuming up to 100% of the available leaf surface of soybeans. Stink bugs were also extremely abundant and caused severe reductions in yields in southern Brazil. Entomological problems are acute in the Neotropics and often form the limiting factor in soybean production.

4. Pest management techniques developed by IAPAR (with help from Dr. Marcos Kogan, visiting scientist), and EMBRAPA (aided by members of the AID/Wisconsin team: Dr. R. G. Hanson, H. C. Minor and E. A. Heinrichs) were discussed and seen in operation in the field. Almost all of the techniques were transferable to other areas and will be incorporated into an INTSOY pest management package.

5. Insects were collected from each field I visited, and these are now being incorporated into the international soybean arthropod collection at Urbana.

6. One of the highlights of the AID/Wisconsin team approach to pest control was the resistant germplasm trials. These were initiated earlier by Dr. Sam Turnipseed (Clemson) and Dr. Marcos Kogan (UIUC) and have expanded greatly under the care of Dr. H. C.

Minor. The trials were under extremely heavy attack by the velvetbean caterpillar and only a few lines showed any degree of resistance to them. Dr. Minor said he would send some seed of these resistant lines to Dr. E. H. Paschal II (UIUC-Puerto Rico) for increase and inclusion in our trials.

XVI. NAME: Goodman, Robert M.

DEPARTMENT: Plant Pathology

COUNTRY: Puerto Rico

DATES: March 11-14, 1975

PURPOSE:

1. To thin, and if necessary rouge, plants in the SMV field experiment planted 25 February 1975.

2. To inoculate plants with SMV in five of the plots of this experiment.

3. To instruct Dr. Victorio Garcia in procedure to use for inoculation with SMV on 24 March.

4. To install a passive trap for collection of aphids in the SMV field experiment.

ACCOMPLISHMENTS:

1. The four purposes stated above were fulfilled.

2. I visited Dr. Goro Kuno, Insect Pathologist at Mayaguez and Instructor of a course in general virology (Biology 533), and delivered an isolate of cowpea mosaic from Puerto Rico for use in his classes.

3. I delivered to Luis Ortiz, Administrator Subestacion de Isabela, a work plan describing the SMV field experiment as requested by Dr. Lidy Lopez, Estacion Experimental Agricola, Rio Piedras.

XVII. NAME: Irwin, Michael E.

DEPARTMENT: Agricultural Entomology

COUNTRY: Bolivia

DATES: March 18-25, 1975

PURPOSE:

1. To become familiar with specific insect pest problems on soybeans grown in various portions of the country.

2. To identify and contact entomologists and other crop protection oriented personnel in soybean production and become familiar with their problems and approaches to soybean pest control.

3. To survey the insects associated with soybeans in the various soybean producing areas of Bolivia, for inclusion in the soybean arthropod collection at the University of Illinois, at Urbana-Champaign.

4. To locate personnel situated in Bolivia willing to cooperate in experiments designed to initiate a pest management program there.

5. To contact the USAID/Bolivia Mission in La Paz and discuss some of their problems and future goals with respect to soybean production.

RESULTS/ACCOMPLISHMENTS

1. With the help of Mr. Max Long, USAID/Utah St. Univ. team, I was able to see all of the important soybean producing areas in Bolivia: the UNDP/FAO experimental station at Abapo, the Santa Cruz area, the Experimental Station at Gral. Saavedra, and the Portachuelo area. At each of these areas, I looked at the insect complexes, and noted the pest species and relative damage to the

crop in relation to how many insecticidal treatments the crop received.

2. To my knowledge I contacted all entomologists and other crop protection personnel in Bolivia. These included among others, Dr. J. Daniel Candia, Dean of Biological Sciences and Entomologists, and Sr. Herbert Zurita O., Oilseeds expert at the Saavedra experiment station; Dr. Sebald Manger, director of the UNDP/FAO project at Abapo; and Ing. Juan Campero R., Entomologist with UNDP/FAO project at Abapo. Of these persons, only Sr. Zurita was actively involved in research activities with soybean insect pests.

3. Collections of soybean arthropods were taken at each of the soybean-producing areas I visited, all of which are now being processed for incorporation into the international soybean arthropod collection at Urbana.

4. I was able to locate one person with whom I feel I could work closely and that together we could initiate a soybean pest management program. Sr. Herbert Zurito O. is that person and he is in charge of the oilseeds and fibrotextile crops on the Saavedra Experiment Station.

5. USAID/Bolivia personnel and USAID/Utah State Univ. team personnel were contacted in La Paz. Important and long-range discussions concerning Bolivian cropping systems and future developments took place.

XVIII. NAME: Irwin, Michael E.

DEPARTMENT: Agricultural Entomology

COUNTRY: Peru

DATES: March 25-April 9, 1975

PURPOSE:

1. To assist in locating Peruvian counterpart personnel for the AID/ta-BOA-1109 task order.

2. To become familiar with soybean production, protection and utilization in Peru and to become acquainted with the various problems involved with the soybean industry.

3. To become familiar with the specific insect-pest problems on soybeansgrown in the various areas of potential soybean production in Peru.

4. To identify and contact entomologists and other crop protection oriented personnel interested in soybean pest management and become familiar with their approaches to soybean pest control.

5. To make a survey of insects associated with soybeans in the various soybean growing areas of Peru.

RESULTS/ACCOMPLISHMENTS:

1. Professional personnel at the Ministry of Foods, Divisions of Production, Marketing and Researdh (including the Agricultural Experiment Stations at La Molina and Vista Florida), at the Universidad Nacional Pedro Ruiz Gallo (Lambayeque) and the Universidad Nacional Agricola La Molin (near Lima), at USAID/Peru, and at the American Embassy, Lima were contacted and fruitful discussions concerning the role of INTSOY and the GOP in developing a National Soybean Center took place. These discussions gave me a good feeling for the type of program the GOP was looking for, and at the same time gave me the opportunity to prepare the various persons contacted for the forthcoming visit of Dr. Carl Hittle. I was able to overlap with Dr. Hittle's

trip to Peru and therefore able to brief him on the situation.

2. During the discussions with the various personnel mentioned above, I was able to become familiar with the major problems facing farmers, marketing and government organizations concerned with the soybean industry and was able to brief Dr. Hittle on these when he arrived in Lima. I was also able to witness first hand in the field some of the problems facing the soybean industry.

3. While in Peru, I conversed with many Entomologists, a few of whom were directly or indirectly involved in soybean pest control. I saw firsthand the major insect and other arthropod pest problems which plagued the coastal growing area. I was unable to visit the interior since soybean production there occurs between May and October.

4. I contacted entomologists and plant pathologists in Peru and found that very little has been done concerning soybean pest control, and no work on pest management has been attempted on soybeans.

5. A collection of soybean arthropods was made at La Molina, to the south of Lima, Chiclayo and Lambayeque, all of which are now being processed and incorporated into our international soybean arthropod collection.

APPENDIX VIII

Publications in the INTSOY Series

Godfrey, G. L. (ed.), Selected Literature of Soybean Entomology, University of Illinois International Agriculture Publications, INTSOY Series No. 1. 221 + xxi pp. April 1974.

Proceedings of the Workshop on Soybeans for Tropical and Subtropical Conditions. University of Puerto Rico, Mayaquez Campus. INTSOY Series No. 2. 184 pp. May 1974.

Williams, S. W., and Rathod, K. L., A Case Study of Expeller Production of Soybean Flour in India. College of Agriculture, University of Illinois at Urbana-Champaign. INTSOY Series No. 3. 12 + iii pp. April 1974.

von Oppen, M. K., Soybean Processing in India: A Location Study on an Industry to Come. College of Agriculture, University of Illinois at Urbana-Champaign. INTSOY Series No. 4. 35 pp. July 1974.

Williams, S. W., Hendrix, W. E., and von Oppen, M. K., Potential Production of Soybeans in North Central India. College of Agriculture, University of Illinois at Urbana-Champaign. INTSOY Series No. 5. 21 + iv pp. August 1974.

Whigham, D. K. (ed.), Soybean Production, Protection and Utilization - Proceedings of a Conference for Scientists of Africa, the Middle East, and South Asia. College of Agriculture, University of Illinois at Urbana-Champaign. INTSOY Series No. 6. 266 pp. March 1975.