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SUMMARY

Work has been conducted on the development of high-protein foods in Geneva and Los Baños. The emphasis has been on developing foods suitable for small children in rural areas in the Philippines. The work at Geneva has included engineering, biochemistry, nutrition, and flavor studies. The experiments in the Philippines have sought to apply the research results obtained at Geneva to conditions in the Philippines and have covered the development of suitable coconut products in addition to soy-based foods.

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C. Training Program

I. Progress in the Geneva Laboratory

A. Engineering Studies

1. Pilot equipment for processing studies at the University of the Philippines, Los Baños

Under the terms of this contract, a pilot plant for the manufacture of new soy-based products is to be established at the College of Agriculture of the University of the Philippines and Philippine personnel trained in its use and the manufacturing processes. In the absence of any processing equipment at the University of the Philippines, the following units have been ordered: steam boiler, water softener, hot water heater, air compressor, steam jacketed kettle, disintegrator, sanitary screw type pump, homogenizer, sterilizing retort, and control instruments. These units are being shipped to this Department's pilot plant for testing and crating before transocean shipment. In some cases, such as the retort, the control system will be mounted on the retort by the Department's machine shop, and all connections tagged before disassembly for shipment. Mr. Jesus Melgar, a Philippine graduate student at Cornell, is to spend six months in this Department's pilot plant becoming acquainted with the operation of the equipment, and he will participate in the tests.

In addition to the above equipment, the purchase of the following items is under consideration pending the cost of the units now on order and the cost of shipment to the Philippines: plate and frame filter press, hammermill, attrition mill, and a cabinet type air dryer.

2. Objectives of processing studies at Geneva

A high-protein milk for feeding infants in underdeveloped countries may be prepared in the form of a bottled liquid or as a powder that is readily reconstituted with water before use. There are at least three methods by which such a product may be prepared:

(a) Dry Raw Process - soybeans → dehulled → ground → powder classified → blended → agglomerated.

(b) Preheated Dry Process (Wenger) - soybeans → dehulled → soaked → heated → dried → ground → dry extruded.

(c) Wet Extraction Process - soybeans → wet ground → heated → filtered → bottled → sterilized.

After a consideration of the alternative processing methods in terms of the needs of the Philippines and the equipment currently available in the Department, the wet extraction process

was selected for current study. The specific objectives of the wet extraction study are the development of a soy milk having the following characteristics:

(a) a flavor as bland as cow's milk

(b) a consistency or "mouth feel" equal to cow's milk

(c) good stability--the solids do not separate on standing

(d) a high yield of protein

(e) a high solids content

In achieving these objectives, there are certain characteristics of soybeans that must be considered. The natural flavor of soybeans is not attractive, and during processing off-flavors may be developed through aerobic oxidation or enzymatic hydrolysis of the fat. There is also a material in soybeans that inhibits the digestion of the protein, and the heat treatment required to inactivate the inhibitor may be detrimental to the quality of the protein. This means that during the wet extraction sufficient heat must be applied as quickly as the beans are broken to inactivate the lipase and trypsin inhibitor with minimal loss in protein solubility.

3. Tentative experimental program for manufacture of soy milk

The unit operations involved in making soy milk will be studied separately in depth and then tested in various combinations until a satisfactory operation is achieved.

Phase I. Wet Grinding

Procedure: Raw soybeans, after cleaning to remove stones, will be ground in the presence of sufficient hot water and steam to affect a maximum liberation of proteins. Success of this operation will also be measured by the energy requirements used in grinding and the ease of separating the liquid. A procedure will be developed for measuring the number, size, and specific gravity of the ground particles.

Phase II. Liquid-Solid Separation

Procedure: The larger particles will be separated for regrinding using filtration, centrifugation, or screening. The desired degree of separation will be characterized by measuring the number, size, and specific gravity of the particles and the protein content of the filtrate.

Phase III. Heating Extract

Procedure: A batch or continuous system will be devised for heating the extract to such temperature and for sufficient duration as required for complete destruction of the trypsin inhibitor. Any changes in the color or texture of the extract after heating will be noted.

Phase IV. Homogenization

Procedure: The particles in the extract will be reduced in size to yield a more stable suspension. For this purpose, a homogenizer, colloid mill, or burr mill will be used. The efficiency of this operation will be judged by the rate of particle separation in the milled extract.

Phase V. Concentration

Procedure: Extract will be concentrated to maximal consistency for drying by use of falling film, rising film, forced circulation, or wiped film evaporator. Viscosity measurements will be made on extract at several degrees of concentration, and rates of evaporation will be noted. Changes in solubility and/or suspension stability will be noted.

Phase VI. Drying

Procedure: Samples of the concentrated extract will be spray dried, double-drum dried, and single-drum dried with the drying operation being altered to include such variables as the use of CO_2 in the feed, different exit air temperatures, concentrations, drum speeds, etc. The resulting powder will be examined for its wettability, stability of the reconstituted suspension, and protein quality. The most suitable powders will be agglomerated to enhance their wettability.

Phase VII. Preparation of Materials Balance and Flow Sheet

Procedure: When all of the unit operations have been tested, a continuous line will be assembled for making powdered soy milk, and a materials balance study will be conducted. A flow sheet will be prepared for the process showing the yields at each step and the desired quality. Quality control procedures will be described for checking the process at critical steps.

4. Experimental results

A preliminary study has been made of some of the variables in producing soy milk by the wet extraction process using equipment available to date. The procedure followed in these experiments was to soak 6 kg of soybeans in 18 kg water at 45-50°C for 2 hours, discard the soak water, and then grind

the beans in the Rietz disintegrator with the desired amount of boiling water. The ratio of hot water to beans was varied as 7:1, 8:1, 9:1, 10:1, and the speed of the Rietz was varied to give 6,500, 9,000, 11,000, and 13,000 rpm. Perforated screens having 0.023- and 0.027-inch diameter holes were used around the fixed hammers of the Rietz. Slurries from the Rietz were homogenized at 4,000, 6,000, and 8,000 psi before filtering through a plate and frame filter. The filtrates were bottled and sterilized in an agitated retort for 5 minutes.

The yields of soy milks having total solids contents of 8.45-10.20% ranged from 61.3-68.3% based on the weight of raw soybeans. Within the relatively narrow range in milk yield, the higher yields were obtained with the higher water-to-bean ratios, slower Rietz speed, and lower homogenizer pressure.

5. Discussion of results

A limiting factor in the yield of soy milks obtained in the above study may be the filtration step. If the filter press acted as an ultra-fine screen, then the solids in the feed slurry would have to be either water soluble or in an extremely fine state of subdivision to pass through this type of filter. Washing the filter cake might increase the yield by leaching out soluble solids. Regrinding the filter cake would also increase the yield of soy milk solids but may require a colloid mill.

To proceed further toward improvement of the yield, more must be known about the physical state of a stable milk, particularly size limitations on the suspended solids. With this knowledge, it is possible to select a means for separating the larger particles and a system for recycling them for additional grinding. This regrinding will undoubtedly increase the yield, but, at some point, the power requirements for achieving this dispersion will become the limiting factor.

A rotary vacuum filter, colloid mill equipped with carborundum stones, and particle size measuring equipment have recently been received, and these units will facilitate the development of the most practical wet extraction system.

B. Biochemical Investigations

1. Increasing the yield of soy milk by pretreatment with enzymes

The actions of various kinds of commercially available enzyme preparations on soy milk and soy milk residue were examined.

All the proteinase preparations (Pepsin, Molsin, Trypsin, Pronase, Prozyme, Nagase, Asp. sojae proteinases, and Thermosin) and the macerating enzyme preparation (Macerozyme) produced a bitter taste in soy milk. However, little or no bitterness was produced from well-washed soy milk residue, when treated with Pepsin and Molsin. Cellulase and Pectinase preparations (Cellulase onozuka, Cellulosin, NBC Cellulase, and NBC Pectinase) did not produce any bitter taste.

Soy milk was coagulated easily at neutral pH by all the proteinase preparations which show proteolytic activities.

As a result of these findings, the experiments in the next step will be concerned with the improved extraction of insoluble constituents from the well-washed soy milk residues by the use of enzymes.

2. Increasing the solubility of dried soy milk by blocking the non-polar groups in the protein molecules

A method to determine the relative redispersibility of soy milk after drying was developed. The effects of emulsifiers on the dispersibility after drying were examined. Experiments adding mixtures of Span 60 and Tween 60 to soy milk showed that the redispersibility of heated and dried soy milks depended upon the hydrophobicities of the emulsifiers, and the maximum dispersibility was obtained around 6.7 on the value scale of emulsifier "Hydrophile-Lipophile Balance". Here the dispersibility of proteins was increased from 20-35%.

Next, the effects of preparation methods on the redispersibility of soy milks after drying were examined. For this purpose, a new procedure for making soy milk was developed, which consisted of homogenizing soaked whole soybeans with acids (HCl, H_2SO_4, and H_3PO_4) at pH 2.8-3.0, neutralizing with NaOH, and then filtering. The resulting soy milk is very much improved in flavor and mouth feel, though a little salty taste is present in HCl-treated soy milk and a little sour taste in H_3PO_4 milks. These tastes can be masked by the addition of sugar. The redispersibilities of the proteins from HCl, H_2SO_4, and H_3PO_4 treated soy milk were 69, 82, and 59% in raw milk and 46, 50, and 21% in heated (95-100°C, 20 minutes) milk, compared with 69% in raw milk and 20% in heated milk prepared in the usual way. The addition of emulsifiers to acid-treated soy milk has not yet been carried out. The results described above indicate the possibility, however, that the soy milk powder having an improved dispersibility of proteins may be produced by the addition of emulsifiers to HCl or H_2SO_4 treated soy milk.

3. Increasing the nutritive value of soy milk by controlling the degree of denaturation of the protein

Apparatus for the high temperature-short time treatment of soy milk has been obtained.

4. Effect of soaking soybeans in sodium hydroxide solutions

A study was undertaken to evaluate the over-all acceptability of soy milk which was prepared from beans pre-soaked in solutions of sodium hydroxide of various pH's followed by a hot extraction. Samples of milk were prepared with final pH's of 6.55, 7.20, and 8.41. These samples were submitted to the members of the soybean research group for evaluation. All members of the group preferred the most alkaline sample. Samples of soy milk were also prepared at five different pH values ranging from 6.56-8.85. These were heat processed at 250°F for 10 minutes to determine the effect of processing on acceptability. The milks were found to hold up quite well under process, the most marked change being a slight darkening of the color.

Two samples were also prepared for amino acid and Kjeldahl nitrogen analysis. Both samples were prepared using a preliminary soaking treatment of 1-1/2 hours at 50°C, followed by thorough rinsing and a hot extraction with distilled water. One sample was soaked in .085 N NaOH (pH 12.7), and the other was soaked in distilled water. The resulting milks had pH's of 7.86 and 6.56, respectively. Both samples of milk were found to contain 7.06% Kjeldahl nitrogen. Amino acid analysis of the two samples indicated that the two samples were very similar in amino acid composition. The effect of NaOH treatment on nutrition must be determined by feeding experiments, however. Work is being planned in this area.

5. Effect of variations in processing on the composition of soy milk

Soy milk was prepared from whole and dehulled soybeans, both soaked and unsoaked, by a water extraction process at temperatures from 25-100°C. Soak treatments consisted of 1, 3, and 5 hours at 25-65°C. The major effect of soaking on composition was to reduce the carbohydrate and increase lipid content. Protein was relatively unaffected. The longer soaks at higher temperatures reduced solids yield, especially with whole beans. Extraction of unsoaked beans at 25-100°C (water temperatures) resulted in maximum solids yield at a 60°C extraction.

The extraction of soybeans with cold water in the production of soy milk resulted in nearly complete oxidation of polyunsaturated fatty acids and esters by lipoxidase in less than 30 minutes

after grinding. This amounted to almost 60% of the total lipid or 18 grams of oxidized polyunsaturated fatty acid equivalent per liter of soy milk of 7.5% solids content. High temperature extraction prevents or reduces the lipid oxidation which accounts for the primary off-flavor developed in soy milk prepared by cold water extraction. Many of the volatile components of soy milk have been identified.

Soybeans were soaked at 70°C for 2 hours, wet dehulled, and deep-fat fried for 3-5 minutes in corn oil at 190°C. The major volatile constituents were 1-octen-3-ol, 2,4-decadienal, pyrazines, and several aromatic and heterocyclic compounds. In this process the whole bean, except for the hull, is utilized. The result is an acceptable nut-like product with wholesome and nutritious properties.

C. Flavor Studies

1. Flavor formation during the dry roasting of soybeans

Work was initiated in this area with the construction of a laboratory size, motor driven, electrically heated roaster which could accommodate a sample size of approximately 200 grams of beans. The roaster is a closed drum type that allows for the trapping of the volatiles emanating from the roasting beans. A collection system was also constructed which could be attached directly to the roaster to allow for the trapping of the volatile flavor components. The collection system consists of a water jacketed condenser and collection flask and a glass wool column soaked with carbon disulfide. The water condenser is used for the condensation of the volatiles which are steam distilled and collected with the inherent moisture from the beans. The glass wool column is placed above the condenser to trap the volatiles coming over during the later stages of the roasting process. Otherwise, these volatiles would escape through the condenser in the form of aerosols.

To date, the work has been concerned with the analysis of the resulting condensates and carbon disulfide extracts through the use of gas chromatography and mass spectrometry.

Mass spectra have been obtained from nine different gas chromatographic peaks. The identity of three of the peaks has been confirmed by comparison to standards. These three compounds are: (1) 2-methyl pyrazine; (2) 2,5 dimethyl pyrazine; and (3) 2,6 dimethyl pyrazine. A fourth peak with a parent mass of 122 could be a trimethyl pyrazine, and a fifth peak with a parent mass of 122 could be a pyrazinealdehyde, possibly 5-methyl pyrazine-2-carboxyaldehyde. Work is presently under way in an attempt to synthesize the latter compound.

A small commercial sample roaster has also been ordered for use in other phases of the roasting work. This unit will be open flame gas fired and will, thus, allow comparison of the effect of open flame and electric roasting. The effect of varying the conditions before and during roasting will be investigated, as well as the effect of roasting on the nutritional value of the beans.

2. Isolation and identification of the green bean odor of soybeans

The volatile component of raw soybeans responsible for the raw green bean odor and flavor has been isolated and identified as vinyl ethyl ketone. The component was isolated by distillation at 40°C into cold traps of dry ice and ethanol or liquid nitrogen. Identification of the component was accomplished by gas chromatography and mass spectrometry.

The raw green bean odor has been cited by many as a major objectionable flavor of soybeans.

A flame ionization detection system was employed on a gas chromatograph. A 10:1 splitter was placed immediately following the gas chromatographic column. The operator was then able to smell the eluting vapors. It was with this adaption that the location of the "green bean" odor was determined.

The resulting chromatogram located the component responsible for the "green bean" odor immediately following a peak with the same retention time as pentanal. This was the only peak that emitted an intense "green bean" odor.

This component was identified using a combination of gas chromatography and mass spectrometry. The gas chromatograph was used to separate the component, and the mass spectrum was determined by direct elution into the mass spectrometer.

The resulting mass spectrum showed a parent peak at M/e 84 and a base peak at M/e 55. A vinyl ketone will fragment giving a base peak of M/e 55 ($CH_2=CH-C^{+}=O$). The difference between the parent peak (M/e 84) and the base peak (M/e 55) would indicate that the remainder of the molecule is an ethyl group (M/e 29).

The spectrum for vinyl ethyl ketone was obtained with an authentic sample. The spectra were exact duplicates. Authentic vinyl ethyl ketone was gas chromatographed, and identical retention times were obtained when compared to the unknown.

The odor of vinyl ethyl ketone is strong and piercing. It is estimated that this compound is present in parts-per-billion quantities in soy milk.

A possible hypothesis for the formation mechanism is the auto-oxidation of linolenic acid.

D. Nutritional Studies

1. Protein quality in deep-fat fried soybeans

Much research has been conducted on soybean products suitable for human consumption in the last few years. Soy milk and synthetic meat products have received considerable attention; however, soybean "nuts" have not been investigated as a possible source of low-cost protein.

Therefore, an investigation has been designed to evaluate the nutritional quality and flavor attributes of deep-fat fried soybeans. The tests being used for evaluating nutritional quality are amino acid contents and PER. The results have not been completed at this time.

Other studies under way include evaluating changes in amino acids as influenced by alkali treatment and the effect of processing conditions on the composition of soy milk.

II. Progress at Los Baños

A. Soy-Based Foods

1. Pilot plant equipment

The U.P.-Cornell project, supported by the Ford Foundation, has supplied Food Science with the following items:

(a) CeCoCo cereal breaker

(b) CeCoCo flour grinder

(c) CeCoCo hand grain winnower

These pieces of equipment are being used to develop processes useful at the barrio level for dehulling and grinding dry soybeans and for producing pre-cooked, full-fat soy flour. These processes are based upon research started at the Northern Regional Research Laboratories, Peoria, Illinois.

2. Soy milk

Mrs. Lourdes David, a student working toward her M.S. degree, has chosen the problem of determining the organoleptic attributes that will make soybean milk acceptable to Filipinos, particularly at the barrio level.

Three varieties of locally produced soybeans have been used to make soy milk: Hsieh-Hsieh, Taichung, and Davao produced in Mindanao.

Soy milks have been prepared by several procedures. Soybeans were soaked overnight in 3 X their weight of water. The beans were drained and the amount of water absorbed during the soaking calculated. They were then ground for 5 minutes in a Waring blendor with water added in the proportion of 10 X the weight of dry beans allowing for the amount of water taken up during the soaking. Beans were ground with water at 100-110°F or ground with hot water 170-180°F. The milks were filtered through a Buchner funnel using coarse filter paper. Milks with and without added flavoring (3% sucrose and 0.1% salt) were filled into 8-ounce soft drink bottles, capped, and sterilized at 15 pounds steam pressure for 10 minutes. Soy milks were also prepared from unsoaked beans using the same proportions of water. The following results have been obtained with Filipino taste panels:

(a) Soybean milks from unsoaked beans were rated unacceptable with or without flavoring.

(b) Soy milk from soaked beans extracted with water at temperatures of 100-110°F were rated unacceptable with or without flavoring.

(c) Unflavored soy milks produced by the hot extraction method were found to be unacceptable.

(d) Soy milks prepared by the hot extraction method and flavored with 3% sugar and 0.1% salt (W/V) were rated acceptable.

(e) There did not seem to be any significant difference in the flavor of soy milks prepared with Taichung, Hsieh-Hsieh, or Davao soybeans.

Soy milks were prepared from soaked beans by the hot extraction method. The soy milks were flavored with 6% sugar with and without 0.1% salt. Although all samples were rated acceptable, a majority of the taste panel preferred the samples containing salt. Salt has not been added to all subsequent soy milks, however, because of a tendency on the part of some soy milks to coagulate in the presence of salt during sterilization.

Seventy-five (75) sixth grade students from two elementary schools in two barrios near Calauan in Laguna were given soy milk samples to drink. The soy milks were prepared from soaked beans using the hot hydration method and contained 5% sugar. Thirty-four (34) of the children found the soy milk acceptable, while forty-one (41) found the samples were not sweet enough. They indicated

that they would like to taste soy milk again in which the sugar content was increased. These studies will be repeated using soy milks prepared with 9% sucrose.

Soy milks have been prepared from soaked beans by the hot extraction process using the proportions of dry beans to water of 1:8, 1:10 (standard), and 1:12 (W/V). These milks will be presented shortly to taste panels to determine how viscosity and solids content influence acceptability. Soybeans also have been dry dehulled and used to prepare soy milks following soaking by the hot extraction process to see if removal of the hulls produces soy milk with a flavor that is more acceptable than the soy milk made from non-dehulled beans. Soybeans are also being prepared with various flavorings, particularly chocolate, to see how it affects acceptability.

3. Soybean curd (Philippine tokua)

Soybean curd is offered for sale on most Philippine markets. It is a product that is well known and accepted by the Filipinos. A related product is tahu which is a softer soybean curd used for dessert. Tokua and tahu are apparently produced by the Chinese manufacturers using traditional procedures. Most Filipinos seem to be unfamiliar with the methods of manufacturing tokua and tahu. Therefore, in all our soy milk studies, we have been teaching the Filipinos how simple it is to manufacture soybean milk and to prepare tokua by heating the soy milk to boiling and precipitating the curd with magnesium or calcium salts.

4. Indonesian tempeh

Tempeh prepared by fermenting dehulled, soaked, partially cooked soybeans with a mold belonging to genus Rhizopus is a standard article of the diet sold in every market in Indonesia. It appears to be unknown among the Filipinos. Project personnel and students have been taught the traditional and laboratory methods of manufacturing tempeh. Sliced thin, dipped in salt brine solution, and deep-fat fried, it has been well accepted by all Filipinos who have tasted it. It is our intention to attempt to introduce tempeh as a cottage industry in a test barrio at a suitable time to see if it will be accepted as a new, economical high-protein food for the diet of the Filipinos.

In the traditional processing of tempeh, the soybeans are dehulled after soaking by rubbing them between the hands and floating the detached skins off the water. The CeCoCo grinders have been adjusted so that the whole dry soybeans can be dry dehulled following treatment for 15 minutes in a hot air oven at 200°F to shrivel the cotyledons. The detached hulls are then removed in the CeCoCo hand winnower.

Tempeh was produced by both traditional and by improved laboratory procedures. The traditional process in which the fermenting bean mass is wrapped in wilted banana leaves would be most easily adapted to small cottage industry in the barrios.

5. Full-fat soy flour by the USDA (Peoria) laboratory

Using the CeCoCo grinders, full-fat soy flour was prepared. Following pre-cooking of the soaked soybeans, the beans are supposed to be sun dried. This has proved to be about a 2-day process when the days are sunny. This is a step when the beans can easily spoil. Therefore, some effort has been made to design and build a simple, hand-operated dryer which can be heated over an open fire or with charcoal.

A gallon metal can was drilled with 150 1/8-inch holes on the sides and ends to allow escape of water vapor. The can was equipped with a handle so that it could be revolved over the fire. It was found that pre-cooked soybeans could be dried in about 2 hours at temperatures of about 70-80°C (158-176°C) in this simple dryer. A 50-gallon drum could easily be adapted for a larger capacity drying chamber.

B. Coconut Products

1. Problems in coconut utilization

Primary effort has been directed toward soy-based food products. However, we are well aware that there is a large potential supply of coconut protein available for food in the Philippines. To be utilized, however, for the human food, the following changes in present processing methods will be necessary:

(a) Present methods of drying the fresh coconut meat will have to be improved to permit rapid drying, to prevent contamination by insects and rodents, to prevent growth of molds and possible production of fungal toxins, and to retain the protein in wholesome, nutritious, extractable condition.

(b) Present methods of expressing oil from the coconut under high pressure and temperature are ineffective in removing all the oil leaving a cake containing anywhere from 6-12% fat. Also, the temperatures involved result in protein that is largely denatured and no longer soluble. In order to prepare a coconut flour containing 20% of high quality protein, it is necessary that the fat be completely removed through low temperature solvent extraction. We are interested in pursuing pilot plant research upgrading the processing of edible coconut starting

with methods of drying the coconut meat, which will require some type of artificial dryer; to solvent extraction of dried coconut meat to remove the oil, which will require an experimental solvent extraction and recovery unit; to extraction and concentration of the protein from the solvent extracted cake. Research is in progress in the Department of Agricultural Chemistry on both the wet and the dry processing of coconut meat. In the wet processing of coconut, Dr. Banzon and his students have shown that the protein distributes equally among coconut cream, coconut skim milk, and coconut pulp. Therefore, wet processing does not seem to be well adapted to extraction of protein from the coconut. Consequently, we hope to obtain a circulating hot air dryer and a solvent extraction and recovery unit necessary for effective research on the dry processing of coconut.

In spite of the lack of certain key pieces of equipment needed for pilot plant research on coconut, some progress has been made in the laboratory on the development of new products from coconut as follows:

(a) coconut milk beverages

(b) methods of dehydrating coconut meat

(c) concentrated coconut water

(d) coconut water wine

2. Coconut milk beverages

Coconut milk was prepared by shredding the fresh coconut meat and pressing it with added water in the proportion of 1:1 (W/V). The coconut milk was filtered through a cloth filter. It was bottled in 8-ounce soft drink bottles with and without 5% added sucrose and sterilized in the bottle for 10 minutes at 250°F.

It was found that the coconut protein coagulates when heated, somewhat like dilute milk-egg custard. Although coagulation occurred, upon shaking, the curd tended to redisperse into a milk. The flavor of the coconut milk containing 5% sucrose was excellent, sweet, and definitely coconut in character. Mixed with soybean milk 1:1 (W/V), it imparted a pleasant coconut flavor to the resulting milk. As little as 1 part coconut milk to 7 parts soybean milk introduced a pleasant coconut flavor masking the usual soybean flavor.

In higher concentrations, the coconut milk could be used as pudding.

3. Simple procedure for dehydrating coconut meat

It was found that the small hand-operated dryer described earlier for drying pre-cooked soybeans could also be used to dry coconut meat.

The fresh coconut meat was first shredded and then dried at temperatures varying from 158-176°F. The resulting dried coconut meat was almost white in color with a minimum of browning. This dried coconut meat can serve as a base for solvent extraction studies.

4. Concentrated coconut water

Fresh coconut water in 40-gallon lots was obtained through the cooperation of Franklin Baker Company at San Pablo City. The coconut water was concentrated at about 130°F in a Rojonnier vacuum evaporator at the General Milk Company pilot plant in Manila. In the first experiment, the coconut water with initial solids content of 3.7% was concentrated to 57% solids. Other analyses of the concentrated coconut water were as follows:

Titratable acidity (as lactic)	- 1.75%
Ash	- 6.55%
Crude protein	- 1.02%
Crude fat	- 1.72%
Color	- light yellow

The first batch received no heat until it was concentrated.

A second batch was prepared in which enzymes and microorganisms were destroyed prior to concentration by heating the coconut water to 190°F. Analytical data on the second batch were as follows:

Total solids	- 82%
Crude protein	- 1.79%
Crude fat	- 1.22%
Ash	- 9.00%
Color	- brown

The second batch, despite its higher solids content, was more fluid than the first.

Both lots of concentrated coconut water were bottled in 8-ounce soft drink bottles. It was found that both lots would remain free of microbial growth without further heat treatment.

Samples of concentrated coconut water were sent to nine industrial firms in the U.S.A. specializing in antibiotic and other pharmaceutical manufacture and to the Northern Regional Research Laboratory (Peoria) for evaluation as to its value as a fermentation stimulator. All groups cooperating indicated their willingness to cooperate in this survey of potential industrial uses for coconut water prior to receiving samples of the concentrated coconut water.

The cooperating laboratories have agreed to report results of their experiments to us. By this survey, we will learn whether or not coconut water is useful in industrial fermentations. This research can only be done in the companies where particular fermentations are already being studied. We hope that it will lead to a new export product for the Philippines.

5. Coconut water wine

Sucrose was added to fresh coconut water to raise the sugar concentration to 22° Brix. It was inoculated with wine yeast 223 (Department of Food Science and Technology, Cornell University, Geneva, New York). In approximately 2 weeks, the alcohol content rose to 12%. The flavor was similar to the rice wine (sake). According to Filipino tasters, it also resembles tuha, produced by fermenting palm juice. It represents another possible outlet for a waste product of the coconut industry.

C. Training Program

Seminars, lectures, and demonstrations of methods of producing soy milk, tokua, and tempeh and the products themselves have been presented to the following groups:

1. Department of Agricultural Chemistry, U.P. College of Agriculture
2. International Rice Research Institute
3. Philippine Women's University
4. U.P. College of Home Economics
5. Maquiling Women's Association
6. Philsugin
7. Annual Meeting of the Philippine Association of Food Technologists

These seminars and demonstrations are considered to be an essential part of introducing and extending information regarding research on soy-based foods under the U.S.-AID contract.

The following persons from Philippine Organizations outside the College of Agriculture have visited or spent time in our laboratory learning the technology of soy milk, soybean curd, and tempeh manufacture for application in other parts of the Philippines:

1. Mrs. Lydia B. Nazareno, Home Economics Coordinator, Lapu-Lapu City Schools (Cebu)

2. Mr. Hilario P. Davide, City Superintendent of Schools, Lapu-Lapu City (Cebu)

3. Mr. Guido R. Ongpin, Manager, Research and Development, Philippine Packing Corporation, Bugo, Cagayan de Oro

4. Dr. Donald H. Smith, Scientific Research Manager, Philippine Packing Corporation, Bugo, Cagayan de Oro

5. Dr. Amado C. Campus, President, Central Mindanao University, University Town, Bukidnon

The Lapu-Lapu City Schools already have a project in which soybeans are grown by the students. Therefore, they are very interested in having the students learn the different ways soybeans can be used in the diet. This will be an interesting project to follow.