PN-ABF-104
ISN 66099

R E P O R T

PRODUCTION AND QUALITY EVALUATION OF SOY PRODUCTS FOR SPU/CIAE/ICAR

Bhopal, Pantnagar and New Delhi, India

January 21 to March 4, 1990

Consultant Report by

Prof. Lun-Shin Wei, Ph.D.

Soybean Processing and Utilization Subproject

Agricultural Research Project (386-0470)

Implementation Order No. 38

Contract No. 386-00000-C-00-5039-00

WINROCK INTERNATIONAL
1611 North Kent St.
Arlington, VA 22209

PRODUCTION AND QUALITY EVALUATION

OF
SOY PRODUCTS FOR
SPU/CIAE/ICAR
CONSULTANCY

PROF. LUN - SHIN WEI, Ph.D.
PROFESSOR OF FOOD SCIENCE/FOOD PROCESSING
DEPARTMENT OF FOOD SCIENCE
UNIVERSITY OF ILLINOIS
URBANA, ILLINOIS 61801
U.S.A.

BHOPAL, PANTNAGAR AND NEW DELHI, INDIA
JANUARY 21 TO MARCH 4, 1990

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- Terms of Reference given by Winrock International at New Delhi.
- Schedule/Scope of activities on SPU - Project at CIAE, Bhopal given by Winrock International at Arlington, Va.
- Final Schedule/scope of activities on SPU Project at CIAE, Bhopal
- Flow sheet for soymilk manufacture (L.S. Wei's unpublished method).

SUMMARY

Three objectives of my consultancy have been accomplished. Products improvement and the technology of new process for dairy analogs and tempeh as well as other were transferred to the SPU Project. Recommendations and suggestion for the SPU future were made and justified in the report.

I. Purpose of Consultant's Visit.

My main task for this mission is to assist the CIAE's effort to develop and produce acceptable soymilk, soy paneer (tofu), dairy analogs and tempeh suitable for home and small scale village commercial utilization.

The second objective is to discuss with SPU scientists on the overview of the world utilization of soybeans and to encourage the continued efforts to promote soybeans for better nutrition through development of highly acceptable inexpensive food products.

The third objective is to advise on the full fat, medium-fat and defatted soy flours quality control and utilization for different indigenous products.

II. Major Organizations/Persons Contacted

1. Winrock International, New Delhi, India Dr. A. Colin McClung, India Coordinator, Mr. P.S. Srinivasan, Administrative Specialist.

2. USAID, India Office

   Prof. John A. Becker, Director - AGRE

   Dr. Surjan Singh, Program Specialist-AGRE

3. ICAR/New Delhi

   Dr. T.P. Ojha, Deputy Director General (Engg)

   Dr. Anwar Alam, Asst. Director General (Engg)

4. CIAE/Bhopal

   Dr. N.S.L. Srivastava, Director

   Dr. Nawab Ali, Project Director

   Dr. R.S. Devnani

   Dr. A.P. Gandhi

   Dr. K.C. Joshi

   Dr. Krishna Jha

Mr. B.S. Bisht

Mr. L.K. Sinha

Mr. P.C. Bargale

Mr. S,D. Kulkarni

Mr. R.T. Patil

Dr. Jaswant Singh

Mr. M.M. Nenwani

Mr. Y.K. Ojha

Mr. B. Mistry

Mr. K.B. Sahu

Mr. U.C. Dube

5. G.B. Pant University of Agri. and Tech., Pantnagar, U.P.

Dr. Mahatim Singh, Vice-Chancellor
Dean, B.P.N. Singh, College of Technology, SPU
G.B. Pant University, Coordinator

Dr. Y.C. Agrawal

Prof. A.K. Tikko

Dr. B.K. Mital

Dr. S.K. Mittal

Dr. V.K. Tanwar

Dr. Gurmukh Singh

Dr. Nirankar Nath

Prof. S.M. Tyagi

Prof. Dheer Singh

Prf. N.K. Sharma

6. Others

- Dr. M.D. Tedia, Director, M.P. State Cooperative oilseed Growers Federation Ltd.
- Mr. D.K. Vakil, General Manager, Central India Flour Mills.
- Mr. Kailash Agrawal, President, G.S. Dhal & Flour Mills Bina and Bhopal.
- Mr. Sunil Agrawal, Executive Director, G.S. Dhal & Flour Mills Bina and Bhopal.
- Mr. Pawan Agrawal, Director, Omni Seeds Private Ltd., Bhopal.
- Mr. S.S. Chitwadgi, G.S. Dhal & Flour Mills.
- Dr. Daya Shankar Singh, Res. Engr., College of Angr. Eng., J.N. Krishi Vishwa Vidyalaya, Jabalpur.
- Mr. Deepak Kumar Maheshwari, Entrepreneur, Jhansi (U.P.)
- Dr. R. Jambunnathan, ICRISAT, Pantancheru P.O. Andhra Pradesh.
- Mr. S.S. Sami, President, Noble Soya House Ltd., Area Colony, Bhopal.
- Dr. Gopal Sharma, General Manager, Noble Soya House Ltd, Bhopal.
- Dr. A.S. Aiyar, Director, Noble Soya House Ltd, Bhopal.
- Dr. N.C. Mungali, Owner, Ahar India, Haldwani, U.P.
- Mr. H.C. Suyal, Manager, Ahar India, Haldwani, U.P.
- Mr. M.A. Menon, Executive Director, Surya Agroils Ltd, Salamatput, M.P.
- Mr. Hemant Kumar Tata, General Manager (Tech.) Surya Agroils Ltd.
- Mr. T.K. Krishnan, Works Manager, Surya Agroils Ltd.
- Mr. Ravi Krishna, General Manager, Britannia Industries Ltd, Soya Complex, Vidisha, M.P.
- Dr. N.K. Sharma, Development Manager, Britannia Industries Ltd, Soya Complex.

III. Consultant's Itinerary and Terms of Reference.

For detail see Appendices (VIII)

IV. Individual Conference with Soy Foods Researcher at CIAE on SPU Project.

The SPU Project under able leadership of Dr. Nawab Ali and Dr. A.P. Gandhi made an excellent progress in developing numerous processes and equipment for home and small scale industrial production of soy products. The on-going research based on what I was able to gather from this conference was well coordinated and inter-related and well planned.

I appreciate very much to have this session arranged by Dr. A.P. Gandhi which gave me a quick overview of their activities on SPU. I thoroughly enjoyed this opportunity to discuss with each individual and to exchange some of technical points without reservation. It was indeed my pleasure to visit with several of researchers I met while ago at the University of Illinois.

The followings are some of the points raised and my specific answer:

1. Fortification of wheat flour/soy flour blend.

   Since the wheat flour made at both G.S. Dhal and flour Mills and Central India Flour Mills are not whole wheat flour or Graham flour, I suggest that B_1,B_2, Niacin and Iron at 2.0 mg, 1.2 mg, 16.0 mg and 13.0 mg per pound of the blend should be added to restore it to the original content of whole wheat. (Ref.USA-FDA, 1971). However, soy flour is noted to be low in Zn, it may be advisable to fortify with a trace of Zn.

2. Method of Vitamin and mineral fortification or enrichment.

   Master mix technique should be used to increase the volume of premix before blending soy and wheat flour in proper proportion with either ribbon mixer or combine two streams in a conveyor.

3. Extrusion of moisturized cracked soybean through Instapro extruder.

While some moisture addition is required for proper cooking in the extruder, adding moisture to cracked soybeans and holding to condition will activate lipoxygenase and causing off-flavor. Therefore, it may be more proper to inject moisture at extruder rather than conditioning.

4. Biochemical/textural changes due to blanching and heating of soybean and rapid assay of protein by Lowry method.

We published some works on texture change as well as activation energy for lipoxygenase and NSI in 1973 and 1982 (J. Spata etal, J. Food Sci. 38, 722 and Brown, B.D. etal, J. Am. Oil Chem. Soc. 59, 88). It should give some of methology we used. For quality assurance program, it is very important to have a rapid method to measure changes in NSI as well as solid and protein content. I encouraged Dr. Joshi to do this work in the planning, which will aid processor to correct processing parameter to give predetermined quality products.

5. Quality improvement at what cost.

A given product always improves in quality with additional effort or cost. One should remember that the improvement of quality is not proportional with effort. Therefore, an economic decision should be made to get a maximum return.

6. It has been reported by earlier researcher that the best NSI of full fat soy flour for baking is about 35 to 45%, while that for defatted was about 50 to 60% NSI. It should also be reminded that the water absorption of flour increase about 1% with every 1% addition of soy flour. Addition of SSL, CSL or EM emulsifier and KBr (at 3.0 to 4.0 mg%) will produce normal loaf volume and result in dough with good handling up to about 12% soyflour fortification. With Indian bread, sweet bread as I experienced here soy flour fortification should not be a problem. (Since it is rather dense, moist and small loaf volume).

I am very much impressed with the proceeding of the National Seminar on Soybean Processing and Utilization in India held on November 1986. It reflects eager of many scientists through out India to endeavor to improve protein nutrition of Indian citizen through renewable low cost foods. Obviously, the task of SPU at CIAE/ICAR coincide with the national Eighth Five-Year Plan to improve, diversification and commercialization of Indian agriculture by the Planning Commission, Government of India.

V. Trial Production of Soy Foods.

Some lecture and experimental direction as well as materials required for my mission were given to SPU Project at CIAE.

One set of my lecture handout for my seminar on the overview of world soybean utilization/processing was also given to SPU Project at CIAE.1

A. Soymilk:

The handout materials for both village and modified Univ. of Illinois, patented soymilk processes prepared by INSTOY/Food Sci. were given to the SPU Project. Because of laboratory and pilot plant in the process of refurbishing, I introduced a modified version of my unpublished method which was viewed successful on my previous mission to EMBRAPA, Brazil a couple of years ago.

The flow sheet of this method is enclosed in the Appendices. However, we started with dry dehulled soybean instead of whole soybeans for 4 hours ambient temperature soaking prior to blanching for 60 seconds. The blanching and hot grinding temperature without monitoring accidentally fell below my recommended temperature to as low as 70-75°C on a trial. The soymilk was still judged by SPU personnels to be acceptable and superior to that of straight hot water grinding.

INTSOY modified Univ. of Illinois patented processes are very excellent methods, I hope that the SPU researchers would test these methods when homogenizer and/or more effective grinder become available.

Flavoring and pH adjustment with NaCl, bicarbonate etc. were published in our paper under Kuntz etel, 1978 and Hitzman et al, 1982 (J. Ed. Sci. 43, 1979 and J. Fd. Sci. 47, 2064).

B. Tofu (Soy paneer):

Soy paneers were made with method given to SPU Project in a wooden mold constructed according to INTSOY design. The $Caso_4$ $2H_2O$, $MgCl_2$-6H2$_0$ and GDL coagulated products showed great promise for application. Most of the taste tester prefer harder paneer produced by $Mgcl_2$ and like it either raw or fried forms. Products were judged to be bland.

Tofu is a coagulated protein product used as a food staply in the Orient for several thousand years. It has been likened to our cottage cheese. It is made from whole soybeans including the hull or from dehulled soybeans. In general, whole soybeans are soaked in water to rehydrate, these are ground with additional water at room temperature to give a slurry, the slurry is heated and filtered through a cloth, usually muslin (known as Momen for cotten in Japnese) to yield soybean milk. This milk is then coagulated by adding an acid such as vinegar or a salt such as calcium sulfate which lowers pH. The resulting pH is about 5.6. Japanese specifications call for a product with high water holding capacity, good elasticity and smooth mouthfeel.

Tofu can be made by starting with whole or dehulled soybeans. Hull removal presents three advantages:

1) bacterial contamination, notably thermophilic spores, is greatly reduced to extend shelf life of fresh and preserved products.

2) The volume of wet sludge produced during manufacture of the soymilk is greatly reduced.

3) increase efficiency and rate of soymilk production with a probable increase in protein yield.

Tofu itself has little characteristic flavor of its own (comparable to yogurt) so it is frequently consumed with other foods in a myriad of combination. The most popular Tofu in the Orient is Momen Tofu. The most desirable characteristic is its thermoplastic elastic texture. This is important; without the particular texture you do not have Tofu. Thus, the objective in making a combination is to impregnate the Tofu gel with flavors that are known, desirable, etc. For instance, as indicated above, one large use is for breakfast; chunks of Tofu curd may be blanched in hot water, drained, diced on the plate, and flavored with soy sauce. Similarly, Tofu cooked in a meat broth takes on the meat flavor.

It should be noted that each of these Tofu food combinations can be prepared for serving in the same ways as described above for Tofu itself, such as deep-fat frying. Thus, characteristics of the food as served will depend on both the other food added and the method of preparation for serving.

There are many receipes have been developed with tofu into familiar foods for most American. Ms. E.E. Gabriel of champaign, Illinois also developed many excellent receipes using locally produced tofu. These receipes are given to SPU project and containing receipes for tofu cream cheese, tofu sour cream, tofu mayonnaise, tofu salad, tofu burgers, Marinade for tofu cubes, tofu-peanut butter spread etc.

Product Attributes

We should like to list these as follows:

1. Protein quality is better than any other vegetable protein.

2. Quantity of protein per serving can be high.

3. The protein/calorie ratio is exceptionally high, over 10 g protein per 100 calories as compared to an average 2.3 recommended for good nutrition. This means that non-protein food can be mixed with Tofu and still get a high-protein food.

4. The oil is both polyunsaturated and cholesterol-free. It is high in lecithin, a phosphatide sometimes called "brain food".

5. Kratzer et al (1959) have been quoted as finding in soybeans an unidentified growth-promoting factor and an antiperotic factor (related to bones and tendons).

6. The oil component contains tocopherol, 9-12 mg per 100 g oil.

7. The original soybean is low in calcium, only one-third that of cows milk on a solids basis. However, calcium is increased to beyond cows milk levels when the Tofu is made by calcium sulfate coagulation. Studies have shown all this calcium is available to humans.

8. Dietary fiber, as discussed above, is low in conventional Tofu. If our studies are successful, this can be increased.

9. Hypertension can be alleviated by eating soybeans according to studies in Europe.

10. Finally, Tofu is a natural food that has been used as the primary protein source by strictly vegetarian Buddist monks for nearly two millenia. One-quarter of the world population, rich and poor, depend on Tofu as a source of dietary protein.

Some important pointers For Tofu Manufacture

Manufacturing condition for any variety of Tofu is designed to give:

1 Maximum solubilization on extraction of protein and lipid into soymilk.

2 Coagulate to make product with high water holding, desired hardness, smooth texture and mouth feel and good elasticity.

1. Regular pressed tofu:

Soaking - Thoroughly wash and rinse beans before soak with 5X of potable water.

Grinding - Water grind with fresh water to give dilution of 10 to 11.

Heating - Higher dilution and high temp. result in harder and smaller volume of tofu; 70-75°C is considered optimum. Generally add coagulant 2 to 3% of dry beans by weight.

$CaSO_4$, $2H_2O$ - gives higher yield and smoother texture, the pH of tofu will lower to about pH 5.5.

$Cacl_2$. $12H_2O$ or $Mgcl_2$, $6H_2O$ - result in harder tofu; Cacl2 reacts too fast and is seldom used commercially.

Forming & Pressing - Remove excess whey by aid of strainer and scoop then pour into muslin lines mold. (10 minutes after coagulant addition). Pressing time about 20 min. with weight. Unfold cloth once during pressing to refold cloth lining to make surface even.

Yield - Maximum, 4-4.5 x dry beans. average, 2 to 4x dry beans.

2. Silken tofu: None pressed type.

Total water addition - include steam condensate, if heated milk by steam injection - 5.5 x Dry beans.

Filter milk yield - about 4 x beans in wt.

Temperature to add coagulant - 70° C to get uniform gel.

Standing time (for coagulation) - 30-60 min. pH higher than normal tofu, 5.8-6.0, when coagulated with Ca SO_4 $2H_2O$

Amount of coagulant — 6g $CaSO_4 \cdot 2H_2O$/1 liter soy-milk

- GDL 0.2 to 0.3% of soymilk. pH lower, 5.5 to 5.7.

3. Bagged tofu- (or Cup) — similar to silken tofu, but heated and coagulated in the container.

Heated - 90°C water bath for 40min. for harder tofu; 70°C for 60 min. for silken tofu.

Beans to water ratio

1 Kg Bean - 4 Kg soymilk, hard tofu
1 Kg Bean - 5 Kg soymilk, optimum

Bag - 1) Polyvinyl chloride (saran) best, heat shrinkable, but more costly. (0.03 - 0.04 mm O.K.)
2) PE of 0.05 mm.

4. Fried tofu : Expanded and non-expanded.

Soymilk - similar to regular tofu.

Heating - heat to 100° C, and cool immediately with cold water to 70° C.

Coagulation - when soymilk cool to 65° C, add coagulant, $CaSO_4$, $2H_2O$. Stir rapidly to coagulate then add 5x water to cool to 50°C.

Cut - after pressing cut tofu into proper size of thin slices, and drain or press excess water.

Oil fry (deep oil) -

1. Fry in 110-120°C oil for 2-3 minutes until float.

2. then move to 180-200o C oil to finish fry to remove surface moisture (about 3 Min.)

If expansion is not desired, fry directly at 180-200°C oil.

Storage: This oil fried and the packed heated tofu if properly cooled before refrigeration can be kept without microbial spoilage for up to two months. The only limitation for fried product is rancidity.

5. **Semi-dried or dried flavored tofu:**

This product is also made from regular cut tofu except on the hard side. It is generally colored with caramel and flavored with sugar or salt etc., to lower aw. The shelf-life of this type product depends entirely on aw of the finished product.

Soybeans
|
Water rinse
|
soak
|
grind with fresh water
|
heat slurry
to 95°C,
and hold for 5 minutes
|
filter
|
cool to 80-85° C
(use high temp. for hardness)
|
add coagulant
|
stand 15 min.
|
pressing (or press in a mold, already divided into small compartment).
|
cut
|
alkaline treatment
(boil in 0.3% NaoH soln. for 3 min.)
|
water rinse (3 times)
|
dyed with caramel color/flavoring
|
dried to desirable
moisture and texture

Storage and handling of tofu (soy paneer):

Shelf-life of tofu and tofu products are widely varied because of the variation in raw bean quality, production facility, sanitation, water quality, method of processing, pasteurization, packaging, storage temperature, handling and etc. It has always been concern of manufacturer, researchers and public health agency. A brief announcement of Taiwan Public Health Bureau, warning consumers to be aware of the perishability, buying and handling of bulk packed tofu as well as pasteurized and packaged tofu, appeared in the vol.19, No.9 September 1987 issue of "Food Industry" published by Taiwan Food Product Res. and Development Institute in Hsin-chu, Taiwan, R.O.C.

Fresh bulk tofu or packaged tofu once opened should be stored in a covered pan filled with potable water in a refrigerator. The water should be changed daily. In about 7 days it may smell slightly sour and becomes slippery to the touch.

The packaged tofu if stored under refrigeration should remain sound for 10 to 14 days depending on the process used. The pasteurized packaged tofu, if pasteurized by heating at 95° C for 40 minutes then cooled, can be stored for as long as two months in refrigeration.

The storage life for tofu packaged or otherwise at ambient temperature should not be recommended for more than overnight or 12 hours.

Frozen Desserts, Ice Cream, Sherbet Analogs from Soymilk

The quantitative composition of soymilk can be made from whole soybean to resemble cow's milk superficially with oil and calcium fortification.

First step in designing a non-dairy frozen dessert is determining a composition. A typical commercial U.S. ice cream contains total solids of about 38.0%, consisting of 10.0% butter fat, 7.5% MSNF (milk solid non-fat), 2.5% whey solids, 12.0% sucrose and 6.0% CSS (corn sugar solids, a low dextrose equivalent CSS, 36DE). A soymilk based non-dairy frozen desserts composition can be achieved by replacing the butter fat with vegetable fats and a non-dairy bulking agent such as low DE, CSS.

Soymilk is free of cholesterol, free of lactose and readily available and easily made from soybean without benefit of cow. Products made from soybeans is beneficial for those with restricted cholesterol intake as well as with lactose or milk intolerance. Several frozen soy desserts formulations developed at INTSOY/Food Science, University of Illinois were pass on to CIAE personnels.

Following are some of additional comments, I would like to leave on this subject:

1. Soymilk: The soymilk used should be of good flavor and bacteriological quality. This goes for other ingredients also. The flavor quality of the finished ice cream cannot be much better than the flavor quality of the starting ingredients.

2. The total solids content of the mix: The total solids content will determine the body of ice cream. A mixture with a low solids may give rise to a weak body and to a texture which may become icy in prolonged storage. An ice cream which has too high solids (about 42%) will result in a heavy or soggy body. The lowest total solids content of ice cream is around 37%.

3. The fat content: This is usually an economic consideration. However, it is generally known as an important factor determining the quality of ice cream. I recommend that fat, a vegetable fat, of proper melting point range of slightly below body temperature, i.e. 96° F, be used at about 10% level in the mixture.

4. The Protein Content: Soymilk for this use should be properly diluted with water to give about 3.0-3.3% protein.

5. The level of sweetners and sugar solids content: Sucrose and CSS are both used to lower freezing point of the mixture. The combine sweetness of the mixture commonly used is about 14 to 16% sucrose sweetness equivalent. Sucrose and dextrose monohydrate combination at about 8.9% and 10.6% respectively in the mix was satisfactory.

6. The stabilizer/emulsifier: An excessive amount of stabilizer/emulsifier may produce a gummy body ice cream. And an insufficient amount will produce a coarse texture product with little resistance to heat shock.

7. Vanilla flavor: A natural vanilla extract, although best in flavor tends to enhance back ground defects. Soymilk as compared to cow's milk, without exception it possesses some defects such as trace of beany or chalky or astringent off-flavor. Our experience indicated that category II Vanillin-Vanilla gives good vanilla flavor without intensifying some of these defects. This comment is also true to that of ice cream made from cow's milk.

8. Freezing points for Non-Dairy frozen dessert mixture should be about follows:

1.	Ice cream	-	20-22°F.
2.	Sherbet	-	20.5-21.5°F.
3.	Soft serve ice cream	-	24°F.
4.	Milk shake	-	26°F.

D. Soy Yogurt.

Dairy yogurts were made with the soymilk prepared at SPU/CIAE. A commercially available (in U.S.A.) mixture culture of Lactobacillus bulgaricus and Streptococcus thermophilus of 1 to 1 ratio freeze-dried culture was revived for this purpose.

Lecture and lab. handout materials were given to SPU project and additional written pointer was also given to SPU project. Products are judged as satisfactory and acceptable.

E. Tempeh.

Tempeh is originated in Indonesia and is an article of commerce in Indonesia. Because of health food popularity, it recently becomes available in U.S.A., North America as well as many European countries. In Indonesia alone, it is said to consume more than 400,000 tons per year.

When sliced and dipped into salt solution before deep oil or pan fried, it is nutty in taste. It is also used without frying by health people on salad, soup as well as pizza topping in the states. It is highly perishable even in refrigerator. Thus, it is normally sold in package frozen.

Procedures for multiplication of Rhizopus oligosporus inoculant as well as preparation of tempeh were given to SPU Project.

Quality changes begin from 6 hours after the termination of incubation. Color and aroma changes from white and nutty to that of yellowish/black and ammonical with time. It becomes ripen tempeh called "tempeh busuk' in about 2 days. This is normally broken or sliced into pieces and sun dried for use in soup. Sun dried product if properly packaged can be kept indefinitely.

F. Hydrolyzed Vegetable Protein (HVP) and Green Soybeans.

Defatted soyflour especially "Okara' (sludge) from tofu preparation contains about 50% protein on dry matter basis. It can be acid hydrlyzed to produce meat like flavor seasoning.

Young immature soybean can also be blanched and preserved frozen as vegetable. It is higher in protein than other beans commercially grown. The feasibility of these should be investigated for SPU Project in the future.

Before, I conclude this section I would like to express my most sincere appreciation for Dr. Krishna Jha for taking initiative on all the experimental work. Encouragement, planning and assistance of Dr. A.P. Gandhi was most helpful. Constant assistance of Mr. M.M. Menwani and Mr. B. Mistry with the lab. operation were greatly appreciated.

VI. Observation/conclusion/Recommendations

I am very impressed with the research proposal shown me by CIAE scientists at our individual meeting. It is well planned and coordinated to support each others progress. I hope that each principal investigator is allowed to spend budgeted funds for purchase of expendable as well as equipment with their own approval without much red tape as in the states.

The proceeding of Nov. 1986 conference on "Soybean Processing and Utilization in India" edited by Drs. Nawab Ali, A.P. Gandhi and T.P. Ojha was very impressive. It showed a large number of scientists beside those in SPU project engaged in researched/developmental work with soybeans.

Dry operation at SPU/CIAE is progressed very rapidly with Mr. Bisht et al's endeavor. However, it still requires additional equipment modification (such as grinding and drier) and obtains more efficient milling equipment. The pilot plant, even for dry operation, require cement floor to be sealed to prevent dust contamination and unnecessary staining. Since the dry operation is and will be in the same room as the wet operation for Takai Tofu/soymilk machine, steam kettles etc. better isolation from wet operation is required.

The wet operation for soy paneer, soymilk, dairy analogs, tempeh etc. at the pilot plant should be completely isolated from the dry operation. The floor should be sealed with floor sealer such as expoxy paint and provide with steam outlet for equipment sanitizing and a floor level water outlet for cleaning and with an adequate floor drain. Of course, the automatic water chlorination should be available for the pilot plant to assure proper residual chlorine in the water used for processing as well as packaging of soy paneer and dairy analogs.

Takai machine is normally provided with a vertical steel coated with carborundum grinder. It requires very careful sanitizing after use. The fineness of ground is related very much not only with spacing but with retention time through the grinder, therefore adjustment is very critical. Shelf life extension research/efforts as well as the variety of soy paneer produced in Japan is most advanced in the world. I suggest that in addition to sending researcher for training at Takai plant, SPU should send a scientist with sound food technological back ground to observe Japanese operation through Takai and/or Dr. K. Saio (Ministry of Forestry, Frisheries and Agri) to see their commercial operation as well as the research at the National Food Research Institute.

G.B. Pant University of Agri. & Technol, showed a great interest in continual participation with SPU and making their main progress through operation at Technol. faculty and Food Technol. Department. I am impressed to see their equipment at both of these Departments. While a large portion of research/development there is done through the dissertation of graduate students, the work such as the study of the factors affecting textual quality of soy paneer, chapati fortification with medium NSI defatted soy flour and its effect on PER, acceptability study of products through student hostel, soymilk extended yogurt and cow's milk etc, were very useful for the SPU Project.

I was very happy to visit Frink Soymilk/paneer/manufacture facility owned by Dr. N.C. Mungali, although, their process of soymilk is with a mechanical cow manufactured in Brazil in 1988. The process as used can be modified further to the full extent as the process I showed at SPU/CIAE. This process was tested to be successful on my last trip to EMBRAPA of Brazil. Mechanical cow in the new process did improve dehuller, eliminate dry grinding of cotyledons, include soaking (hot) and bicarb blanching, replaced centrifugal separator with rotary screen okara separtor, raised hot water temperature to near 100°C for grinding replaced plate oil heat exchange to tubular heater at higher temperature etc.

The process as was done should result in a very low NSI soaked cotyledons. Therefore, the protein content of soymilk, 8 litre/kg dry beans, will be very low and bulk of protein will be lost in okara. I suggest SPU project should look into these and pass on my procedure and report to all participating SPU scientists.

Operation and facilities at other plants visited showed great promise by its' own or is a potential entrepreneurs for out-reach/technol. transfer of SPU findings.

I strongly suggest SPU project to obtain and install etc. of the followings:

1. Build on the top of lab. ceiling a floor strong enough to support storage carbinets. A simple temperature control chamber can be fabricated with a bagasse board with heating from light bulb and air circulation by an electric fan etc. These chambers can be used for a constant temperature storage as well as accelerated storage study using Q_{10} principle.

2. Purchase portable thermocouple temperature measurement devices for every research scientist so accurate process temperature control is possible.

3. Fabricate home, mechanical, frezen dessert freezer.

4. Purchase (additional) for wet pilot plants:

   a) a small 2 stage homogenizer capable of operating at 4,000 psi.

   b) a soft serve ice cream freezer

   c) an ice cream freezer

   d) a colloid mill or Fryma mill (these are manufactured and available in India)

   e) a small plate heat exchanger - for heating and cooling of liquid.

   f) a tubular heat exchanger with provision for heating and ice water cooling.

   g) Install a large double stainless steel sink for washing and cleaning of utensils at pilot plant.

   h) purchase proper sanitizer for the cleaning of wet processing equipment.

5. add two Food Tech./Food Tech. Dairy to the SPU Project to increase capability for food processing component.

6. To encourage entrepreneurs to start with multi-products approach to start soy food business.

   As mentioned above, the SPU objectives coincide with Indian Government 8th 5 year plans set forth by Indian Agri. Planning Commission. Additional research, equipment funds should be secured from ICAR etc. usually, it takes about 2-3 year for any programme to be organized. I am impressed with the progress of SPU in such a short time under the leadership of Dr. N. Ali.

I am glad to learn that it is in the process of one year renewal. I hope such a worthy project deserve consideration for further renewal for a much longer period. The ICAR should restore more of its fundings to processing and utilization programme.

The SPU objective and U.I. INTSOY/Food Sci. are the same. The INTSOY's main objective is to improve human nutrition with soybeans. INTSOY had established world wide research/education efforts. INTSOY researchers, such as Prof. A.I. Nelson et al under the leadership of Dr. H.E. Kauffman develop new process and product continuously. Therefore I recommend highly for SPU to work in close cooperation with INTSOY.

VII. Acknowledgements

I wish to express my sincere appreciation to all officials and personnel I contacted at Winrock International in Delhi, Winrock International in U.S.A., ICAR, CIAE, USAID in India, and G.B. Pant University of Agri. & Technology.

My special thanks to Dr. A. Colin McClung for welcome letter waiting for me at Hyatt upon my arrival and his taking time to meet me at his office. With Mr. P.S. Srinivasan's assistance in every detail of the local arrangement, travel/scheduling and coordination, my mission come to a successful completion. I am very fortunate to have secretarial assistance from Miss Lissyam Joseph, Mr. Theodore Xalxco and Mr. Shabbir Husain. Mr. A.K. Dubey's daily driving to work at Bhopal is greatly appreciated.

Scientific colleagues and administrators at ICAR, Dr. T.P. Ojha and Dr. Anwar Alam and CIAE personnel were all very helpful with my mission. I wish to express my special thanks to Dr. N.S.L. Srivastava, Dr. Nawab Ali, Dr. A.P. Gandhi, Dr. K. Jha, Dr. K. C. Joshi, Mr. B.S. Bisht, Mr. L.K. Sinha and Mr. S.D. Kulkarni.

My tour of G.B. Pant University of Agri. and Techol. was both useful for SPU mission and an enjoyable one. I am especially grateful to Dr. Mahatim Singh, Vice-Chancellor, Dean B.P.N. Singh, Prof. A.K. Tikko and Dr. S.K. Mital.

Finally, I would like to thank Dr. Floyd Williams advice for travel to India and kind arrangement given by Mrs. Surbhi Bhatt, Ms. Gunier Gary and Dr. Williams' assistant, Fay.

VIII. Appendices.

- Terms of Reference given by Winrock International at New Delhi.
- Schedule/Scope of activities on SPU-Project at CIAE, Bhopal given by Winrock International at Arlington, VA.
- Final Schedule/Scope of activities on SPU Project at CIAE, Bhopal.
- Flow sheet for soymilk manufacture (L.S. Wei's unpublished method).

DR L.S. WEI
SHORT-TERM CONSULTANT -- SPU PROJECT
JANUARY 22 - MARCH 3, 1990

During the six-week assignment in India, Dr Wei will perform the following duties:

1. To hold discussion with the Project-Director, SPU, and the Director, CIAE, Bhopal, and to evaluate status and needs of the Sub-Project.

2. To hold discussions with the Scientists working in the area of production of fullfat soyflour (FFSF), MFSF, and defatted soyflour, and fermented products.

3. To hold discussions on latest developments in soybean processing and utilization technology.

4. Quality evaluation and utilization of full fat and defatted soyflour in different indigenous food products.

5. To standardize the production process for fermented products like Tempeh, etc, their quality evaluation, and utilization.

6. Preparing analytical technologies for the quality assessment for different soy products.

7. To submit written report summarizing consultancy activities and recommendations to the sub-project.

8. To give an oral de-briefing to ICAR/USAID and Winrock before departure from New Delhi.

SCHEDULE/SCOPE OF ACTIVITIES OF DR. L.S. WEI IN SPU PROJECT AT CIAE, BHOPAL FOR SIX WEEKS

Area/Scope of work : Production and quality evaluation of soy-products (Flour, Milk & Dairy Analogs)

Proposed period : Feb. 15 - March 31, 1990 (Six Weeks)

Date	Activities
February 15, 1990	Arrival, Discussions with PD, SPU and visit to SPU Labs.
February 16-17, 1990	Discussions with SPU Scientists working in the field of quality evaluation and product development
February 18, 1990 (Sunday)	REST DAY
February 19-24, 1990	Identification and adaption of technology for soymilk production at rural level.
February 25, 1990 (Sunday)	REST DAY
February 26-March 3, 1990	Improvement in shelf life of soypaneer (Tofu) under tropical conditions.
March 4, 1990 (Sunday)	REST DAY
March 5-10, 1990	Adaption of technology for TEMPEH production and its quality evaluation including shelf life.
March 11, 1990 (Sunday)	REST DAY
March 12-17, 1990	Production and quality evaluation of dairy anologs (curd/yoghurt and icecream) from soybean.
March 18, 1990 (Sunday)	REST DAY
March 19-24, 1990	Production and quality evaluation of dairy anologs (curd/yoghurt and icecream) from soybean.
March 25, 1990 (Sunday)	REST DAY
March 26-29, 1990	Finalization of process and equipment for milk, paneer, tempeh and dairy anologs and report writing.
March 30-31, 1990	Discussion with ADG(Engg.), ICAR and USAID/Winrock Officials at New Delhi and Departure.

Schedule/Scope of activities of Dr L S Wei in SPU Project, CIAE, Bhopal during January 23, 1990 to March 1, 1990

Area/Scope of work : Production and quality evaluation of soyproducts.

Sitting/working place : Consultant Room (CPE Building/SPU Lab)

Counterpart Scientists : Dr K C Joshi/Dr Nawab Ali

Office working hours : 0930-1630 hrs (1300-1330 hrs, lunch break)

Date	Activity	Contact Scientists/ Technicians
1	2	3
January 23	Arrival at Bhopal. Stay at Jehanuma Palace Hotel. Discussion with Director CIAE/PD, SPU and visit to SPU Lab.	Dr KC Joshi/Dr AP Gandhi/ Dr Nawab Ali
January 24	Discussions with all SPU Scientists on various R&D activities in which they are involved.	All SPU Scientists
January 25	Discussions with the Scientists working in the area of production of fullfat soyflour (FFSF), MFSF, defatted soyflour and fermented products	Dr AP Gandhi/Mr BS Bisht/ Mr SD Kulkarni/Mr LK Sinha/ Dr K Jha/Dr KC Joshi/ Mr RT Patil
January 26	Holiday (Republic Day) /Discuss with Drs Jha & Joshi on Soyfood	
January 27	Seminar and discussions on soybean processing and utilization programmes in around the world.	Dr Jaswant Singh/Dr KC Joshi/ Dr Nawab Ali
January 28	Rest Day (Sunday)	
January 29 to February 3	Identification and adaption of technology for soymilk and HMP production at small scale	Dr AP Gandhi/Mr BS Bisht/ Dr KC Joshi/Ku N Awasti/ Mr YK Ojha/Mr RN Tripathi/ Mr MM Nenwani
February 4	Rest Day (Sunday)	
February 5-9	Improvement in shelf life of soypaneer (tofu) under tropical conditions and use of okara as a food ~~in the~~ meal	Dr AP Gandhi/Dr K Jha/ Dr KC Joshi/Mr YK Ojha/ Mr RN Tripathi

/31/90 Wei-London at CIAE

1	2	3
February 10	Rest Day (Second Saturday)	
February 11	Rest Day (Sunday)	
February 12-15	Production of fermented products like tempeh, quality evaluation and utilization	Dr KC Joshi/Dr K Jha/ Dr AP Gandhi/Ku N Awasthi/ Mr RN Tripathi/Mr MM Nemwani
February 16-20	Visit to Pantnagar	USAID/Winrock International
February 21-28 with Feb. 25 Sunday (Rest Day)	Production and quality evaluation of dairy analogs (curd/yoghurt and ice cream) from soybean	Dr AP Gandhi/Dr K Jha/ Dr KC Joshi/Ku N Awasthi/ Mr RN Tripathi/Mr MM Nemwani/ Mr Y K Ojha
March 1	Departure to Delhi	Dr KC Joshi/Dr AP Gandhi/ Dr Nawab Ali
March 2-4	New Delhi. Work in ICAR/USAID/WINROCK INTERNATIONAL AND DEPARTURE TO USA.	

Visits: To a few soybean processing units around Bhopal/Indore.

(A P Gandhi)
I/c Project Director
Soybean Processing & Utilization Project

To
Distribution among SPU Scientists

Whole soybean
placed in Wire Basket
Rinse and wash with cold tap water

↓

Soak in tap water for 4 h. to overnight until beans double in weight. (Place the wire basket into bucket filled with cold water.)

↓

Drain and fresh water rinse (lift basket from bucket and water rinse from top of the basket).

↓

Immerse basket with soaked bean into boiling water (water temperature after immersion should not be less than 90°C) - lift and lower the basket up and down for 3 times. (So no cold spot in the beans at the center of the basket); blanch for total of 90 seconds.(60 seconds if soaked dehulled beans are used)

↓

Cool the basket of beans in a bucket of cold water thoroughly, so center is not warm to touch.

↓

Grind in Waring blender with boiling water (8 parts water to 1 part dry beans) at high speed for 3 minutes.

↓

Filter → (Okara) Sludge can be used as pan fried pattie with wheat flour as binder and garnished with onions, etc.

↓

Filtrate - Soy milk

For Beverage
Add following:

↓

Heat to boil and simmer for 10 minutes

1. 0.05% $BaHCO_3$
2. 0.2% NaCl
3. 4% sugar
4. Flavoring:
   a) cocoa at 0.6% (increase sugar to 7%)
      or
   b) coconut milk enough to flavor
      or
   c) Trace of vanilla Extract

↓

Cool to room temperature with running water before bottling

↓

Refrigerate