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Overseas Trip Report

Stanley P. Clark and Karl F. Mattil

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During the latter part of October and early November, 1969, Mr. Stanley P. Clark and Dr. Karl F. Mattil made a reconnaissance survey of research pertaining to or related to the utilization of fresh coconuts in the production of food products. The purpose of the survey was to determine the status of research efforts that were known to have been conducted as well as those that were presently underway.

Advice from a number of sources guided us to centers of coconut research in England, India, Ceylon, Thailand and the Philippines. On the advice of Dr. Ragnar Ohlson, Vice President of Research, Karlshamn, we visited the Biochemical Institute at the University of Uppsala and the Alfa-Laval Company in Tumba, both in Sweden. The food industry in Sweden has encouraged the Biochemical Institute to undertake an investigation of the food use potential of rapeseed, a project which parallels in many ways the Texas A&M project with coconuts, and Alfa-Laval is very interested (in both rapeseed and coconut processing).

Because single cell proteins do represent a potential competitor to coconut or any other unconventional proteins, and because it was believed that the industries involved, not being established protein companies, might be using some fresh, non-traditional approaches that, if divulged, could be useful, we contacted three companies who are in the forefront in SCP, two in England and one in Japan.

The first section of the report is a chronological record of the information and impressions we received from our many conversations. While we

have tried to record and report as accurately as possible, if we did misinterpret or misunderstand any of the persons with whom we talked, we apologize.

The second section of the report summarizes our impressions, conclusions and recommendations.

We express our sincere appreciation to the many people who helped us plan this survey, and those who spent many hours telling us about their work and answering our questions, and particularly to Mr. Philip W. Ruppert, USAID/Philippines, for much assistance and down-to-earth commentary.

THE BRITISH PETROLEUM COMPANY, LIMITED
Britannic House
Moor Lane
London, E.C.2, England

October 13, 1969

Mr. Gordon H. Evans, Research Co-ordinator
Research and Technical Development Department
Mr. D. L. Knights

British Petroleum is working on two processes from different petroleum feedstocks to produce yeast containing about 65% protein. One process uses a straight-chain paraffin feedstock and the product does not require solvent extraction of residual paraffin. The other process uses a relatively heavy gas-oil fraction from refinery by-products and requires solvent extraction to remove the petroleum residue. The most information on British Petroleum processes for yeast production from petroleum are contained in an article in Hydrocarbon Processing for March, 1969. This publication has considerable information on their processes, but no secrets are divulged. Other references on the subject are Chemical Week for August 2, 1969, and Chemical Engineering for August 26, 1968.

British Petroleum expects to be selling the products for animal feed next year. The economics of their process are such that they do not expect to be able to compete for animal feeds in the U. S. market. However, they do believe that they can compete in the British and European markets. In Britain, 44% soybean meal is sold at 50 pounds ($120.00) per long ton. Fish meal with 65% protein sells for 80 pounds (192.00) per long ton. They think that they can compete successfully against these prices.

A policy decision has been made by the top management of BP that for the present they will direct their attention exclusively toward the animal feed market. Consequently, they are doing essentially nothing about possible uses in foods. It was apparent that the management's decision has not prevented Mr.

Evans and Mr. Knight from thinking about food applications. Because of this, they are rather unhappy with the name "petro-protein". They feel that this could be a negative in the food industry. We suggested to them that if they created the image of their product as being an animal feed, the transition to food use would be somewhat handicapped. People would continue to think of it as an animal feed.

BP have made isolates from their petro-protein, and have run pH-solubility curves. They have also demonstrated on a laboratory scale that these isolates can be spun.

In designing their clean-up procedures, BP have used the Food & Drug Administration standards for FPC to evaluate their product. They believe that the protein they are now making meets all the requirements the FDA has established for FPC, and do not expect any problem with FDA approval unless FDA comes up with some new arbitrary position as they did with FPC. A strict interpretation of present food laws in the United Kingdom would prevent the use of petro-proteins under any circumstances. These laws state that no food shall contain anything that has been made from or which has included a petroleum product. BP seems to believe that this law can be changed.

Mr. Evans said that he will send us a sample of their product if he can get top management approval. This may not be given until after top management has decided to give active consideration to food applications.

The BP petro-protein has been rather extensively tested both in ruminants and in non-ruminants. One pig that was held as a reserve in a comparative feeding test had its ration adjusted to where it was including up to 65% of the petro-protein as the protein supplement. The pig grew well and no abnormalities were evident when the pig was slaughtered. A ham made from this pig was considered to have a normal taste.

RANKS HOVIS MCDOUGALL
Lord Rank Research Center
Lincoln Road
High Wycombe
Buckinghamshire, England

October 13, 1969

Professor P. Spicer
Dr. G. L. Solomons

Dr. Spicer has the title Professor as somewhat of an honorarium. There has been concern in England about the lack of communication between research people in universities and industry. To bridge this gap, universities have been giving academic appointments to selected scientists from industry. Dr. Solomons came to Ranks Hovis from British Petroleum two years ago and is conducting a fermentation research program.

This company is the largest food manufacturer in Britain. Their operations include freeze-drying of eggs, baking of bread, and milling of wheat. Dr. Solomons is in charge of work which is attempting to develop processes for the production of protein from various carbohydrate materials that are by-products of their milling processes. They are using fungi because they believe that the fungi have the least problem with nucleic acids and a built-in advantage due to the fibrous structure of the fungi.

Professor Spicer believes that it will be very difficult to produce food proteins using bacteria because these contain up to 12% of the nucleic acids. Yeasts are intermediate with 7-8% and fungi are lowest with 3-5%. Professor Spicer believes that the research done at MIT is convincing evidence that nucleic acids are biologically harmful. He said that British Petroleum has a process for reducing the nucleic acid content of their products using intracellular ribonuclease. This process was developed in cooperation with Dr. Steve Tannenbaum at MIT who has a patent assigned to the Sloan Institute.

Solomons believes that he can produce a 40% protein product using fungi at a cost of between 12 and 15 cents per pound. He says that the material has a naturally fibrous character which he believes will be compatible with some meat products. It has a nutty flavor that should be acceptable in some food systems. Professor Spicer indicated that if we should find an interest in using the waste fiber from coconut for fermentation, he would be willing to provide assistance to the program.

Of particular interest to us was a bread that Ranks Hovis is producing that was developed in their research organization. This bread is sold under the trade name "Nimble", and is sold as a diet food for weight control. It is a low density bread and each slice weighs substantially less than a normal slice of bread. Nonetheless, the bread has the appearance and texture of their ordinary white bread. This is made possible by blending native flour with partially denatured gluten. The denatured gluten retains its extensibility but is sufficiently denatured that it does not produce toughness. The native and denatured glutens are carefully blended to a formula that is 25% protein and produces a high quality loaf of bread under conditions of continuous dough manufacture. The process is a trade secret and is not patented. Professor Spicer says that Ranks Hovis has no plans to enter the international market with this bread. We examined and tasted a sample of the bread and found it to be fully comparable to the typical British bread. Obviously it is less dense than ordinary British bread.

Spicer has seen several plants in Russia where protein is being made from the cellulose of wood pulp by acid hydrolysis followed by fermentation. The proteins are being used for animal feeds. He believes that their processes are uneconomic, but that they do not have good enough cost accounting to know

what their costs really are. He does not consider the cellulases to be very promising at this time, as those presently in use are only effective on fairly pure substrates.

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TROPICAL PRODUCTS INSTITUTE
56/62 Gray's Inn Road
London W. C. 1, England
and
Culham Abingdon
Berkshire, England

October 15, 1969

October 16, 1969

Dr. David A. V. Dendy
Dr. Brian E. Grimwood
Mr. Winston Timains
Mr. A. W. James

Dr. Grimwood evidently is rather of a public relations officer in the organization and Dr. Dendy, who had been with them only about one year, directs their development laboratory and pilot plant. Mr. Timains is a process chemical engineer and Mr. James operates their research bakery.

Tropical Products Institute was founded 75 years ago as part of the British Ministry of Overseas Development. Its purpose is to help developing countries, both within and without the Commonwealth, to gain greater benefits from their plant and animal resources. It has five departments: Food Science and Technology, Non-foods, Economics, Industrial Technology, and Tropical Stored Products Center. It has a staff of about 350, more than a third of whom are scientists, engineers, and economists. The budget for 1969-70 is 795,000 pounds.

TPI has had an interest in the production and utilization of coconuts for quite some time. They have been working on processes for recovery of protein from fresh coconut for 5 or 6 years, but only in the past year have they had one chemical engineer assigned full-time to the project.

Dr. Dendy felt that there were three reasons why the processes that have been developed over the past 15 or 20 years have failed to become commercially viable:

(1) unfavorable economics

(2) bad siting of plants in areas where the supply of coconuts was inadequate

(3) lack of basic information for process optimization.

In their development work, they have used random coconuts as obtained, and have found that the maturity of the coconut has a substantial effect both on its processing characteristics and upon the nature of the products obtained therefrom. Dr. Grimwood commented that the agronomic conditions under which coconuts are grown undoubtedly influence their properties substantially. For example, he said that if coconuts are grown in a sulfur deficient soil the copra is rubbery and therefore is rather difficult to process.

TPI has developed a process for removing the coconut meats from the shell. They submerge the coconuts in water in a pressure tank and then build the pressure up to 50 or 100 pounds using air pressure (we were given these two different numbers by two different individuals). The coconuts are held at this pressure for about 60 minutes. Under these conditions, it is believed that the water is forced through the shell of the coconut and causes the coconut meat to shrink. The pressure is then released slowly over a period of about 20 minutes. If the pressure is released rapidly, the meats apparently expand and once again are difficult to separate from the shell. However, if the conditions are as prescribed, the shells will separate easily from the meats. They said that Goodrich Products of 137 Sierra Street, El Segunda, California, 90245 have developed a coconut sheller but they do not know how successful it has been.

TPI has developed, on a pilot plant scale, a process for making protein isolates from fresh coconut. If they remove the testa, the protein is white, but if the testa is left on, the protein is light brown. We were given samples of each of the two types of protein.

They believe that paring should be avoided if possible, because of the cost of this operation and also because the oil and protein in the paring end up in a copra-like product of lower economic value.

In the TPI process as presently developed, coconut meats are milled with an equal weight of room temperature water. The mixture is screened to separate fiber from an emulsion. The fiber is pressed to recover as much emulsion as possible. The emulsion is acidified to about pH 4. The acidified emulsion separates by gravity into four phases, namely: oil, oil-water emulsion containing protein, an aqueous layer containing carbohydrates in solution, and coagulated protein on the bottom. At present, the acidified emulsion is centrifuged, the protein sludge is collected and dried by ethanol or isopropanol. Along with the water, alcohol removes some of the oil which is carried over into the protein.

They have found the milling of the coconut meats to be an extremely important operation. Their objective is to put the cellulose into a condition that it can be separated from the emulsion using a shaking sieve. If the milling is not properly done, yields of oil and protein will be low and the separation will be difficult. In the pilot plant, we saw a stainless steel meat grinder of British manufacture which is reported to do a satisfactory milling job. It was said to be comprised of a wedge-shaped impeller which forces the material through holes about one millimeter in diameter. The operation is both cutting and extrusion. The closer the wedge is to the dieplate, the better the ex-

traction they get. They have tried a colloid mill, but found that it disintegrated the fiber to such a degree that it was difficult to separate from the emulsion by screening. The projected commercial process has milling in two stages, by a dicer and a crusher.

The screens used in the pilot plant are of the vibrating type like those manufactured by the SWECO Company. The screen is about 30 inches in diameter, of stainless steel. The one observed on the machine was 120 mesh, although 200 mesh was given as the usual size. By the procedure outlined, when using a 200 mesh screen, only a small amount of fiber is collected on a 300 mesh screen in series.

At present, the fiber from the screen is re-extracted with water to increase the yield of protein and oil. Single extraction with only a single stage is desirable and it is hoped that this will ultimately prove to be feasible. The fiber contains nearly all of the oil lost, which amounts to 10% to 15% of the total, plus about 20% or more of the original protein. Work is being conducted on the development of a dewatering press to squeeze oil and emulsion from the fiber. Expeller pressing of the fiber has been tried in a Japanese "Hander" screw press. However, satisfactory expeller pressing requires drying of fiber, and this they do not want to do if it can be avoided. Processing of the fiber to achieve maximum oil and protein recovery, and to find a use for the fiber, is considered to be among their major problems.

The emulsion from which the cellulose has been removed is coagulated by acidulation to a pH of about 4. The acidified emulsion is then put through a three-phase centrifuge with a 6" disc bowl and at this point they encounter their most serious problem. Instead of three phases, they have four. The top phase is mostly oil and the bottom phase is mostly coagulated protein. The

second phase from the bottom is an aqueous layer which they said contains very little nitrogen. However, at the interface between the aqueous layer and the oil layer, there is an emulsion that contains both protein and oil. They have not been able to find a means yet for the effective recovery of oil and protein from this layer. Both Dr. Dendy and Mr. Winston Timmins, the chemical engineer who has been running the pilot plant, emphasized repeatedly that they would like to know more about the physical chemistry of the coconut emulsion system. They believe that there may be two different proteins that behave differently. They raised the question whether the material in the interface layer might be a lipoprotein. In their judgement, the separation and recovery of the oil and protein in this interface layer will be the key to a viable process.

Presently, TPI is washing traces of moisture and fat from their precipitated protein by extraction with ethanol at room temperature. The protein is then dried at ambient temperature. We raised the question whether this extraction was causing any denaturation and they did not know. As stated earlier, they have given us samples of their protein and we have agreed to run some functional tests of these proteins and supply them with the information we obtain. They were not making any functionality tests, and were quite interested in our approach. (We have looked at their two samples in a preliminary way. They contained 79% and 91% protein, but were substantially denatured as measured by pH-solubility profiles. Because of their low solubility, no further functionality tests will be made.)

The principle use they appear to have in mind for the coconut protein is as a supplement in bread. Mr. A. W. James, who is in charge of bakery research, has been experimenting with the use of cassava flour in blends with

wheat flour. He showed us some of the loaves of bread that he was baking and the cassava had a rather marked detrimental effect upon the texture of the bread. They have been using the coconut protein at a 3% level to bring the bread back to a normal protein content. The quality of the bread they were making with cassava (47%) and coconut protein (3%) was definitely substandard.

TPI may set up a coconut processing pilot plant either in Ceylon or in Barbados. We suggested to Dr. Dendy that it could be useful for us to collaborate in the development of processes for fresh coconuts. He appeared to be receptive to the suggestion. We asked whether he would be agreeable to having somebody from our staff spend a couple of weeks in his pilot plant and he promptly agreed. We feel that this is a very important contact and that we should maintain a constant flow of communications with Dr. Dendy.

Grimwood and Dendy mentioned that they understand that work on coconut is being done at Stanford University. A pilot plant is rumored to be under construction on the island of Samoa by an American firm.

* * *

INSTITUTE OF BIOCHEMISTRY
University of Uppsala
Uppsala, Sweden

October 17, 1969

Biochemistry Institute:
- Professor Jerker Porath
- Dr. S. A. Lieden
- Dr. J. C. Janson
- Dr. Von Hofsten (Biochemistry Institute)
- Dr. Von Hofsten (Institute of Biology)

Also Present:
- Dr. Ragnar Ohlson, Karlsham
- Mr. K. Gillis Een, Alfa-Laval
- Mr. Reino Sepp, Alfa-Laval

After a tour of the laboratory, Professor Porath's staff presented a seminar on their work with rapeseed. This work was undertaken in large part at the instigation of segments of the food industry, as represented by Dr. Ohlson. Alfa-Laval are deeply interested because they believe that centrifugal approaches (such as at TPI) have substantial potential (Alfa-Laval makes centrifuges). The seminar was of considerable interest and encouragement to us, inasmuch as this very prestigious protein research group is taking essentially the same approach to rapeseed that we are to coconuts.

Dr. Von Hofsten of the Institute of Biology is making a study by electron microscopy of the cellular structure of rapeseeds. Her most interesting observation was that in the center of the protein bodies is a vacuole which she believes cortains the anti-nutritional factors of rapeseed. She has no direct evidence that these are anti-nutritional factors, but has some presumptive basis for believing that they are.

Three extraction processes have been used to produce rapeseed protein. In the first, rapeseeds were rolled and water extracted. Proteins were separated from some of the other extractables by gel-filtration. The solid residue after protein extraction was dried and solvent extracted to recover the oil. In the second process, the rapeseeds were rolled and dehulled. The oil was solvent extracted, the residue was water extracted, the protein was separated from the water extract by dialysis. In the third process, rapeseeds were rolled, the oil was solvent extracted at room temperature, the residue was water extracted at pH 11.7, and the extracts were purified by gel-filtration at pH 10.

Water extraction in the first process was tried at pH 8 and also at pH 11.7. The protein from pH 8 extraction gave growth rates comparable to

casein. The results of toxicity testing showed some pathological liver cells. Protein extracted at 11.7 remained partially in solution at pH 4, so gel-filtration was required for recovery. Protein from the second process also gave growth rates comparable to casein, but the toxicity has not been measured. In the third process, the water extract at pH 11.7 was stable against bacterial growth for several days. Extraction at pH 11.7 recovers about 90% of the protein. Recovery at pH 8 is about 50%.

We saw a pilot plant under the direction of Dr. Janson, which is capable of processing ten kilograms of rapeseed. It has a Sephadex gel-filtration unit with a column about two feet in diameter. They believe that gel-filtration has commercial possibilities, particularly when one is trying to remove a rather small amount of unwanted components. Their present goal, however, is simply recovery of sufficient quantities of rapeseed proteins so that they can be characterized by molecular weight, isoelectric point, amino acid analysis, biological activity, and solubility.

The Institute is naturally concerned with the materials in rapeseed which are considered biologically undesirable. These are thioglucosides, of which they say there are six in rapeseed. They contend that these materials are not toxic but simply anti-nutritional.

* * *

ALFA-LAVAL AB
Tumba, Sweden

October 17, 1969

Mr. K. Gillis Een, Director of Engineering
Dr. John A. Aspegren, Director, Research and Development Group Staff
Mr. Rune Glimenius, Processing Engineering
Mr. Walter Hoffmann, Manager, Process Development
Mr. Reino Sepp, Manager, Process Laboratories
Mr. Egon Wagemann, Research Engineer
Mr. Sven-Eric Kroon, Sales Engineer

The Alfa-Laval people were very interested in the possibilities of centrifugal processing of oilseed for protein. They are attempting to keep in touch with all developments around the world in this field. Dr. Aspegren appeared to be particularly interested in coconuts. They have developed a centrifugal processing procedure for "petro-proteins". They did not volunteer any of the details of the process, presumably because they developed it in co-operation with some company which is active in the field.

Mr. Wagemann had some photomicrographs of coconut meats showing cells about 50 microns across by 150 microns long. Apparently the cell walls are fibrous and contain the oil and protein within them. They have conducted some experiments on milling of coconut to release the oil and protein. They emphasized the importance of milling upon the efficiency of recovery of oil and protein. They found the most success on a small scale with a cylinder containing glass beads one millimeter in diameter and a stirrer operating at 3000 rpm as an attrition mill.

They said that this is the same type of mill that is being used experimentally with single cell proteins. Only after this mill was used, could they get nearly all of the cells opened and the oil and protein released as shown by microscopic examination. This milling was conducted at a neutral pH. Centrifugation in a tube formed three phases: cream, water, and solids. They said that the separation of the oil and protein phase is difficult, and that it ultimately may be solved by the use of surface active agents (detergents).

A Sephadex fractionation system for cheese-whey has been developed by the Swanson Company of St. Paul, Minnesota. When asked to compare the merits of gel-filtration with membrane filtration, Mr. Aspegren said that he

felt gel-filtration would be applied where fractionation was desired and membrane filtration would be used for concentration.

Alfa-Laval feels that having to separate oil from fiber, as in the TPI process, is undesirable.

* * *

THE PROTEIN FOODS ASSOCIATION OF INDIA October 20, 1969

Mr. A. V. Mody, Vice Chairman, P. F. A.
Unichem Company
Bombay, India

Mr. Mody is presently Vice Chairman of the Protein Foods Association and it is expected that he will be the next Chairman. The Association is a group of about twenty-five Indian companies interested in the promotion of new protein foods. They have made modest financial contributions to establish the Association whose present activities are centered primarily around market surveys.

Mr. Mody is the owner of Unichem, a pharmaceutical company. This company has several hundred detail men contacting physicians and drug stores. Consequently, Mr. Mody is looking for ideas of foods that he can sell through contacts of this sort.

He is presently experimenting with a cookie (an Indian biscuit) which includes pre press solvent extracted peanut flour obtained from the Tata Oil Mills Company. This biscuit is formulated to supply a substantial quantity of well balanced proteins. Like everybody else in India, with very few exceptions, Mr. Mody is more inclined to be interested in the protein efficiency ratio than in any other characteristic of his product. However, he is a practical businessman who has become aware of the importance of consumer acceptance

and has in fact scaled his ideas of the required protein content for the biscuit down from his original thinking of 25% to his present product which is about 18% protein. This was done to make the product more acceptable to the consumers.

Mr. Mody is progressive and receptive to new ideas. However, his products must be limited to those which can best be marketed through his doctor detail men. We suggested that he might consider marketing a coffee whitener or a tea whitener, inasmuch as rather large quantities of boiled milk are used for this purpose in India.

Mr. Mody expressed interest in products which could be produced by continuous cooker extruders such as mixtures of cereals with oilseeds or oilseed products. He is also interested in the possibility of marketing a blend of wheat flour enriched with peanut flour. Customarily, Indians purchase wheat and have it ground into flour or take it home to grind. This is reputed to be due, in part, to the fact that Indians distrust purchased flour assuming that it might possibly be adulterated. Mr. Mody recognizes that packaging a fortified flour will cause manufacturing problems and increase the cost.

* * *

THE TATA OIL MILL COMPANY, LTD. October 21, 1969
Sewri
Bombay-33, India

Mr. D. K. R. Rao, Manager of the Oil Mill
Dr. B. P. Baliga, Director of Research
Dr. N. L. Murty
Dr. K. S. Holla
Dr. M. Rajasekharan

In India, about 70% of the coconuts produced are used for edible purposes, chiefly for making curries. The fiber of coconuts has a strong

tendency to absorb fat. When dry, it will absorb 60% of its weight as fat. Dr. Baliga suggested that the most feasible process for producing coconut protein was to dry the coconut meats, extract them with solvent and then extract the protein from the residue. For wet centrifugal processing, he suggested milling the coconut meats with added coconut oil instead of water as a possible means of preventing the formation of emulsions. Dr. Rajasekharan had worked on coconut processing at the Central Food Technological Research Institute in Mysore. Dr. Rajasekharan said that one of the problems with the Kraus-Maffei process at Mysore was the large amount of fiber leaving the press along with the emulsion causing the isolated protein to be high in fiber. In addition, the oil loss in the expeller cake was too high when the feed rate to the press was high enough to be economically feasible.

In Bombay, Tata produces a high quality food grade prepress solvent extracted flour some of which is sold, and the majority of which is used in the manufacture of their isolated peanut protein. The quality of peanuts they use for this operation cost them about eight dollars per ton more than ordinary peanuts. The peanuts are cleaned, blanched and hand picked as if they were going to be eaten as nuts. Then they are screw pressed in one V. D. Anderson expeller. The press cake is accumulated until enough is on hand to make a run in the oil mill solvent extractor. This was reported to be a V. D. Anderson vertical emersion type column with a capacity of forty to fifty tons of prepress cake per day. It has a steam jacketed screw conveyer type of desolventizer.

The specially processed prepress solvent cake is ground into flour in the same area where the cleaning and sorting of peanuts and the prepressing are conducted. The flour is bagged.

Processing in the protein isolation plant is a combination of batch and continuous. Extraction and pH adjustment are batch operations and the drying is a continuous operation. All of the equipment is stainless steel with sanitary dairy type of construction including piping and pumps.

Bags of flour are elevated to a second floor level and dumped by hand into floor hoppers over mixing tanks where room temperature water is added. After mixing, the batch of slurry is run into a basket centrifuge where the insoluble materials are separated from the extract. At the present time, the insoluble materials are discarded. The pH of the extract is adjusted to 4.8 to 4.9 with 5 N sulfuric acid and the protein precipitates. The acidified extract is centrifuged in a continuous centrifuge which discharges a stream of water and a stream of protein solids in the form of a slurry. The aqueous phase is discarded. The protein slurry is neutralized with sodium hydroxide solution, spray dried and bagged.

Hydrogen peroxide is added to the extraction water to aid in the control of bacteria and to provide some bleaching effect on the protein isolate. There are also some indications that hydrogen peroxide aids in the elimination of aflatoxin. Dr. Baliga said that their isolate is consistently devoid of aflatoxin.

The two basket centrifuges performing the first centrifugation are German Kraus-Maffei imperforate basket type with automatic sequencing. Each receives a charge of slurry while spinning. The supernatant is discharged by a scoop with an adjustable depth of travel. Then the solids are also discharged by a scoop.

The centrifuges separating the acid precipitated protein are Danish Titan valve operated machines. Valves in the bowl are opened on a variable

time schedule to allow the solids to be discharged from the disc bowl. The water discharged from both centrifuges was milky but the milkiness was said to be caused by entrained air. The nitrogen content of the water was said to be low.

The pH of neutralization before drying often is adjusted to the customer's specifications. The spray drier is a Danish Niro vertical cylinder with a cone bottom. The drying air is heated to about 200°C. by passage through tubes in an oil fired furnace. Material leaving the drying chamber is cooled by chilled air immediately and then screened. This is mixed with material from the cyclone dust collector and is bagged in an air-conditioned cooled room.

The plant was reported to be running continuously six days per week with four-hour shutdowns for complete cleanup every two days. The selling price of peanut flour is 0.7 to 1.0 rupees per kilogram (4.2 to 6.0 U. S. cents per pound) and of isolated protein is 3.5 to 5.0 rupees per kilogram (21 to 30 U. S. cents per pound).

The Tata Oil Mill Company operates another peanut protein isolate plant at Ahmedabad. This plant uses raw peanuts as feed stock. While the basic process was developed at the Central Food Technological Research Institute in Mysore, Dr. Baliga told us that Tata was the only organization which has thus far industrialized the process. Tata was producing about 100 kilograms per day of the isolated protein for use in a new chocolate flavored drink containing about 5% total solids which they were attempting to market. Naturally, the protein produced by this process is more soluble than that obtained from the prepress solvent flour.

In this process, an aqueous slurry of raw peanuts is fed to a three phase centrifuge to produce three product streams: oil, protein extract and

a slurry of insolubles. One change that Tata made from the original CFTRI process and which improved their results was the substitution of a different make of three phase centrifuge for the one originally installed. Presently, their recovery of oil is only 80 to 82% of the theoretical amount available. Dr. Baliga believes that the affinity of the fiber for oil is the cause of the low oil yield and he believes that this problem will be worse in wet coconut processing. Tata also has some emulsion problems similar to those which have been encountered by the Tropical Products Institute people. Dr. Baliga says that Tata has been getting better separation in continuous centrifuges than tests in a batch centrifuge had indicated they could expect.

It was our impression that Tata had lost some momentum on peanut protein products during the nine to ten months that Dr.Baliga was in the United States. Evidently, Baliga was largely responsible for much of the earlier movement of the products through his personal contacts in the food industry. According to a telephone conversation with Mr. Charles Puttkammer from the U. S. Embassy in Delhi, a number of companies were quite annoyed with Tata because of their very poor handling of this protein business. We received the distinct impression that the market potential for peanut protein products in India is good but that the marketing capabilities within the Tata organization were considerably less than effective.

* * *

CENTRAL FOOD TECHNOLOGICAL RESEARCH INSTITUTE October 23, 1969
Mysore, India

Dr. H. A. B. Parpia, Director
Dr. B. L. Amla, Assistant Director for Information and Extension
Mr. G. T. Ramanathan, Assistant Director for Engineering and Process Development

Dr. M. R. Chandrasekhara, Director of Protein Technology
Mr. N. Subramanian
Mr. G. Ramanathan

It appears that the CFTRI has not done anything with the processing of fresh coconuts for several years. Dr. Parpia indicated that they have no plans to initiate any projects unless they are requested to. Consequently, their present technology does not extend beyond the reports in the literature of their work with the Kraus-Maffei process.

The CFTRI discontinued work on their modification of the Kraus-Maffei process because they could never achieve more than about 80 to 85% of oil recovery. Again, the big negative appears to have been the absorption of oil into the fiber. The present technology of screw pressing copra to 7 or 8% residual oil in the cake represents a 95% recovery of oil. It is believed that any new process must approach this level in order to be an economic success. India simply cannot afford the loss of coconut oil. It is used primarily for soap and cosmetics. Evidently it is very highly thought of both in India and in many other Asiatic countries, not only for grooming of the hair but also as a body oil.

Their coconut processing pilot plant has been partially dismantled when units of equipment were needed in other research. We did see the Kraus-Maffei disintegrating roll which is essentially a shredder followed by two rows running together at about 400 to 500 rpm with some differential in speed. The K-M dewatering press had a perforated cage with openings of 0.05 to 0.10 millimeters. To prevent blinding, the holes were narrower on the inside than on the outside. A pin mill was reported to be the best device for shredding fresh coconut prior to K-M pressing. They used a K.E.K. pin mill manufactured at Ancoats, Manchester, England.

The use of a colloid mill to mechanically break the emulsion produced in the K-M process met with some success. A description of these experiments has not been published. Solvent extraction of expeller cake from the K-M process resulted in good oil yields but the protein recovery was only about 60%. CFTRI has also done some experimentation on the removal of water and oil from undried coconuts by azeotropic extraction with heptane. However, when asked what they believed would be the process most likely to be successful for the recovery of proteins from fresh coconuts, Mr. Rammanathan said that he felt that the coconut meats would first have to be dried and solvent extracted prior to the isolation of proteins.

CFTRI has tried making protein isolates from copra expeller cake. When they used alkali extraction with acid precipitation,they obtained a poor flavor and color. With acid extraction, the flavor and color were satisfactory but the recovery was only about 60%. They tried enzyme digestion followed by extraction and found that the protein then could not be coagulated. They presumed that it must have been hydrolized. The nutritive value of this enzyme extracted protein was found to be low. The enzyme was obtained from Japan.

CFTRI indicated some interest in a beverage made from coconuts. They have done some experimenting with a so called "skim milk" produced by the centrifugal separation of coconut milk into cream and skim milk fractions. Although there seemed to be some difference of opinion of the actual protein composition of a typical skim milk, the only analysis immediately available from their records showed 2.6% protein, 0.8% oil, 5.4% carbohydrates, 1.4% ash and the remainder water. Obviously for the skim milk idea to be successful, it would be necessary to develop processes for recovering useful marketable products from the cream.

The principal product of interest at present in CFTRI is a peanut protein made from solvent extracted peanut flour. We tasted a development product called "Lac-Tone", so called because it is a 50% mixed cow and buffalo milk "toned" with peanut protein dextrose and water to a fat content of 1.5 to 2%. Normally, "toned milk" is fresh milk mixed with dried skim milk and water to lower the fat content by one-half, or in the case of "double toned milk," by three-quarters. "Lac-Tone" could be considered to be doubled toned.

We also saw both wet and dried precipitated peanut protein with which they were working. In the pilot plant, they were attempting to use recentrifugation of precipitated peanut proteins to increase the total solids content of solutions going to the spray drier from the range of 10 to 15% up to 20 to 30%.

The pilot plant was quite well equipped with good process equipment, most of it stainless steel and sanitary design for food use. It was housed in a large, well lighted building designed for the purpose. Some of the principal items of equipment in addition to those mentioned earlier are as follows:

Westphalia Model SAOG-205 Centrifuge with 700 to 800 liters per hour capacity for separation of three phases using intermittently opening valves for solids discharge from the bowl;

Westphalia Model SKOG-205 Centrifuge for separating three phases using continuously open nozzles of different sizes for solids discharge from the bowl;

DeLaval DVK-4G Three Phase Nozzle Type Centrifuge for separating yeast from fermentation liquor;

Sharples Decanter Centrifuge with solid horizontal bowl for relatively easily conducting two phase solids-liquid separations;

Three Disc Bowl Two Phase Laboratory Size Centrifuges;

A small centrifugal Liquid-Liquid Solvent Extractor of German manufacturer;

A Danish Anhydro Spray Drier having 25 to 30 liters of water per hour drying capacity equipped with an oil fired heat exchanger to heat the air;

A Plate-Type Liquid Pasteurizer;

A small Horizontal Flaking Row;

Two Alcohol Recovery Stills which permit alcohol to be concentrated to 95% and from 95% to near absolute;

A small Blaw-Knox Buflovac Drum Drier having drums approximately 6x12 inches in size;

A larger Drum Drier of their own design and manufacture having drums approximately 12x24 inches in size (they are presently making a still larger Drum Drier);

A British APV Company Plate-Type Evaporator having very low contact time for work on high viscosity products;

A Forced Circulation Evaporator;

A chilled water supply to the evaporator condensors;

A Nash Pump for providing a vacuum of about 25 inches of mercury to the evaporators;

A Continuous Drum-Type Vacuum Filter of stainless steel;

Several Cabinet-Type Driers;

Hammer Mills;

A Mikro Pulverizer with stainless steel cyclone collector;

A pilot size stainless steel V-Type Solids Mixer.

Dr. Parpia said that he had recently visited Oregon State College and the University of California at Davis and had pointed out to them where their Food Technology program was deficient in preparing students for useful careers in developing countries. He said that he spent two days at each institution discussing with them the kind of curriculum he feels would be most useful to people who would be coming into laboratories such as his or others in India.

* * *

HINDUSTAN LEVER
Sewri
Bombay-15, India

October 24, 1969

Dr. S. Varadarajan, Research Director
Dr. K. K. G. Menon, Head of Biological Research
Dr. S. S. Kalbag, Head of Process Development

We met only briefly with Dr. Varadarajan and were impressed that his approach to product research appears to be very highly academic. Dr. Menon is definitely biologically oriented and appears to be primarily concerned with nutritional and anti-nutritional factors. Dr. Kalbag, who rather recently came from CFTRI and is a graduate from Purdue University, appeared to be by far the most practical of the three. At CFTRI, Dr. Kalbag worked on the peanut protein process.

Dr. Kalbag was of the opinion that the high fiber content of coconuts makes the recovery of oil by wet processes impractical. Therefore, he believes that a process for the recovery of coconut protein should start with solvent extracted coconut solids.

Hindustan Lever is interested in developing a coconut milk that is not made from coconuts. They feel that coconuts are too expensive for this

purpose. However, they have encountered the problem that there are no coconut flavors available that they consider acceptable. They feel that the flavors that are available are more like that of copra than of fresh coconut.

Dr. Menon pointed out what may be a rather important fact, that is, coconuts are reported to be sensitive to amoebic infestation. This should be checked out very carefully. If true, it should be taken into consideration in research on development of new food uses for coconuts.

Dr. Menon also believes that the nutritional aspects of oilseed carbohydrates is an area where more attention is needed. Past nutritional work with oilseed proteins has to a great extent ignored the nature and biological properties of the associated carbohydrates. Presumably, he is concerned about the reports of gastrointestinal symptoms induced by unfamiliar carbohydrates.

* * *

COCONUT RESEARCH INSTITUTE OF CEYLON
Bandirippuwa Estate
Lunuwila, Ceylon

October 27, 1969

Dr. W. R. N. Nathanael, Director

The Coconut Research Institute is concerned primarily with production problems and is supported largely by a check off system of coconut producers. In Ceylon, agricultural acreages greater than twenty acres are called "estates" while those under twenty acres are called "small holdings".

The use of nitrogen, potassium and phosphorous as fertilizer improves coconut yields. The Sinhalese government subsidizes fertilizer costs by 50%. The average production of coconuts in Ceylon is 2400 nuts per acre per year. The Coconut Research Institute is producing hybrid trees whose nuts average

about 50% larger than normal. One of the objectives of the hybridization research is to produce trees that do not grow so tall. Not only do trees that are more than fifty years old fall off in production but in addition they presently become so tall that harvesting becomes a problem. One of the services that the Institute performs is to provide seedling trees to farmers.

Coconuts set new flowers every month. It takes twelve to thirteen months for the production of a mature coconut. In Ceylon, it is the practice to harvest every two months. At each harvest, the pickers select the two ripest bunches to remove from the trees. Presumably these will be the coconuts that are twelve and thirteen months old. Dr. Nathanael said that there is no significant difference in the composition of coconuts at twelve and thirteen months. They do not wait and allow the mature coconuts to fall. In falling, the coconut shell might be split and if that does happen the coconut deteriorates rather rapidly.

Dr. Nathanael said that dehusked coconuts may be stored two to three months if kept in a shaded place. However, if they are allowed to remain in direct sunlight, the differential in temperature on the sunny and shaded sides may cause the coconut to crack. For maximum stability in storage, the tuft over the three eyes of the coconut should not be removed. It is at this point where spoilage most easily begins. Normally, coconuts are not stored very long after harvest.

The price of coconuts in Ceylon is about 15 to 20 Sinhalese cents each and the price of king coconuts is 75 cents each. The king coconuts are a separate variety that are used primarily as a source of beverage. Laborers at the Institute were being paid 3 rupees per day and skilled labor, 5 to 7½ rupees per day.

Dr. Nathanael said that about half of the coconuts produced in Ceylon are used for food. The average consumption by Sinhalese is 140 mature coconut kernels per year. This does not include the immature king coconuts which are harvested at six months. Of this tremendous utilization of mature coconuts, most people make homemade coconut milk. This is done simply by grating or scraping the coconut meats and then straining them through some device such as cheesecloth. It is general practice to discard the residue which contains about 35% fat on a dry basis. Presently the Oils and Fats Association are collecting this residue from some sources and using it to extract coconut oil for use in splitting into fatty acids. However, their collections represent only a small fraction of the residue that is available. Because of this large consumption of coconuts and of legumes imported from India, Dr. Nathanael believes that protein malnutrition is not a problem in Ceylon. The coconut milk that is produced in the home is used as a base for curries which are used with rice. The coconut residue constitutes a considerable waste on the scale that it occurs in Ceylon.

Lever Brothers-Ceylon are marketing a product called "Coconut Cream" which is intended to replace the home preparation of coconut milk for curries. This is a concentrated coconut cream, a one pound packet of which is said to be the equivalent to the milk of six coconuts.

Dr. Nathanael was, like many other Sinhalese , a strong proponent of the water from the king coconut. He stated categorically that the water from the king coconut is more valuable nutritionally than that from a mature coconut. He said that it contains 4% glucose and various unidentified growth stimulant and diuretic agents. Later conversations suggest that this opinion is based more on folklore than on science. The king coconut is harvested at six months

simply to provide a beverage. The end is chopped off the coconut using a heavy knife to form a natural cup and the water is then consumed and the remainder of the coconut thrown away. To the Sinhalese, this is a very refreshing drink but it appears to be a very wasteful use of the coconuts.

For making copra, coconuts are husked, shelled, split and spread to air dry for one day on a platform raised above the ground. Twelve to fifteen percent moisture reduction is accomplished in this period of time. Drying should begin within four hours after the nuts are split, otherwise spoilage will begin. Copra should be protected from rain during drying. Some completely sun drying is conducted in the dry areas of Ceylon, however, most copra is produced by a combination of one day of sun drying followed by five days of kiln drying using coconut shells for fuel. About two-thirds of the shells are consumed in this way. The objective of drying is to reduce the moisture content to 6%. Such copra will have satisfactory storage qualities. The temperature reached inside the kiln is about 80°C.

In Ceylon, copra is graded into "edible" and grades 1, 2 and 3. Edible or white copra is produced by so called "patent driers" or by using a smokeless coconut shell charcoal as fuel in the kilns. Dr. Nathanael said that most of the edible grade coconut was exported to India where it received a premium price inasmuch as it produces a good quality oil which is used for food and cosmetic purposes without refining. Later conversations with the people at Lever Brothers suggested that the export to India was not as large a component as had been inferred by Dr. Nathanael. The copra is graded according to color, brittleness and degree of deterioration. Dr. Nathanael tried to show us samples of the edible white copra but none of the samples that were brought in came up to the standards he said were required for shipment to India.

Copra is subject to growth of molds and fungi if not properly dried causing a lowering of the grade. Aflatoxin is found in this copra. Drying at too high a temperature can also cause a lowering of grade. Copra is also subject to insect infestation. The Coconut Research Institute has developed construction plans for kilns and complete instructions for copra manufacture, which if followed carefully, are reported to insure production of good grades of copra.

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INSTITUTE OF SCIENTIFIC AND INDUSTRIAL RESEARCH
31 Torrington Place
Colombo 7, Ceylon

October 28, 1969

Mr. S. F. Laurentius

Mr. Laurentius had worked at the Tropical Products Institute in England for one year ending last August. He worked on several phases of the TPI coconut process. He said that when they used a colloid mill for grinding the coconuts, the maximum extraction of oil that they obtained was 86%. When they set the mill to obtain a maximum oil extraction, the fiber would be ground so finely that it would cause the mill to choke. For example, at 0.005 inches setting on the colloid mill, the feed rate was low and the mill was likely to choke and in addition the screen used to separate the fiber was easily blinded. On the other hand, at a setting of 0.02 inches on the colloid mill, the operation was much smoother but the oil recovery achieved was 86%. They were seeking a 90% oil recovery as a minimum.

Mr. Laurentius described the process developed by ICAITI in Guatemala. This process was very similar to the TPI process except that a rod mill was used for disintegrating the coconut meats. In the ICAITI process, coconuts

and water were passed through a rod mill to produce an emulsion. The emulsion was screened to remove the fiber and then passed through a centrifuge. Their major effort was to produce an unstable emulsion so that the oil could be released and separated in the centrifuge. According to Mr. Laurentius, ICAITI never succeeded in producing such an unstable emulsion and have ultimately abandoned the process.

Laurentius is working on a process for the commercial manufacturing of coconut milk or coconut cream. He uses a two to one water to coconut ratio which produces a slurry which separates into a cream and a serum. The cream represents 70% of the volume and after homogenizing and pasteurizing, can be used for curries. The serum which is about 2% solids represents 30% of the volume and contains primarily carbohydrates, minerals and some small amount of nitrogen. When the serum was spray dried, it could not be reconstituted. He has found that with the use of sodium lauryl sulfate, the oil content of the fibrous residue can be lowered to as little as 3%. He said that when the emulsion is acidified, the oil and protein can be separated by filtration at the temperature of Sinhalese laboratories. However, he was not able to do this at the temperature of an English laboratory. The Ceylon Institute of Scientific and Industrial Research is continuing to work on the wet processing of coconuts.

Mr. Laurentius feels that it is important to find a use for the fibrous residue. It apparently has a tremendous affinity for fat and we suggested the possibility of utilizing this property. Subsequently, the thought has occurred to us that this property could constitute a serious disadvantage if foods containing substantial quanities of coconut fiber were ingested. They probably would be excreted almost quantitatively and might carry with them substantial quantities of dietary fat and fat soluble vitamins.

Mr. Laurentius believes that the best use of coconut protein isolate would be for the fortification of bread. He believes that the school age population should be the first target. He stated that the villagers do buy bread. The Sinhalese government has a monopoly on the import of flour, therefore it could be easy to incorporate coconut protein into the flour if the government would decide to do so. He has tried flour made from coconut expeller cake in bread at 5%, 10% and 15% levels. The 5% addition caused a noticeable change in the quality of the bread and the 10 and 15% additions produced unsatisfactory quality bread. He has not tried flour made by the direct solvent extraction of coconuts.

Mr. Laurentius estimated that 40% of the coconuts produced in Ceylon go to domestic use and 60% for industrial purposes. The latter includes desiccated coconut, copra, coconut oil and exported coconuts. It is his opinion that any new coconut process would have to compete with the desiccated coconut industry for raw material because competition with the copra segment of the industry could cause serious economic dislocations.

Mr. Laurentius mentioned the Asian Industrial Development Council whose members are the Philippines, Ceylon, Thailand and India. This group has a coconut committee which is supposed to coordinate work among these nations on coconut processing

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LEVER BROTHERS-CEYLON, LTD.
P. O. Box 283
Colombo 14, Ceylon

October 28, 1969

Dr. J. A. D. Lanerolle
Mr. Daya Senanayake

The per capita consumption of coconut milk in Ceylon is 2 ounces per day. Meat consumption is limited. Dried fish is largely imported. The residue from copra expeller mills is used now for feeding cattle. Ceylon has a limited supply of animal feed. If more coconut protein were deverted to human consumption, Dr. Lanerolle believes that it would necessary to import animal feed.

Lever Brothers-Ceylon is marketing a new product called "Coconut Creem". According to the label declaration on the carton, "Coconut Creem" is composed of coconut fat, milk proteins, carbohydrates and added vitamins A and D. It is packaged in one pound units in a plastic bag inside a rectangular cardboard carton similar to a butter carton. The product is white, has no odor and looks much like a soft shortening. The selling price is 1.9 Sinhalese rupees per pound.

Dr. Lanerolle stated that the sales appeal of "Coconut Creem" was expected to be convenience. It will replace the home preparation of coconut milk which is a time consuming operation. A one pound package will make about the same amount of curry as six coconuts. To prepare the curries, the "Coconut Creem" is blended with appropriate quantities of water.

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APPLIED SCIENTIFIC RESEARCH CORPORATION OF THAILAND October 30, 1969
Bangkhen, Bangkok
Thailand

Dr. C. Lewis Wrenshall, UNIDO Advisor
Dr. Kasem, Director
Dr. Sman, In Charge of Food Technology

The Applied Scientific Research Corporation of Thailand was set up by an act of the Thai government. Dr. Wrenshall is assigned there as a

representative of the United Nations Industrial Development Organization. Their principal areas of interest are food, building materials, metallurgy, industrial chemicals, medicinal plants and the technology of fiber products from jute and kenafe.

Dr. Wrenshall stated that most of the coconuts produced in Thailand are consumed as food and that the supply just about equals the demand. Thailand does not manufacture copra but does import coconut oil for use in soap. We asked what protein supplement was used for livestock and Dr. Wrenshall said that the water buffalo subsists on grass and hay.

In home use, the coconuts are scraped to make coconut milk for curries and the residue is discarded much as is done in Ceylon. Dr. Wrenshall would like to see the production of coconut milk commercialized inasmuch as this would make it possible to double the yield of milk from the same supply of coconuts. In making milk, he feels that it must be made from pared coconuts with the testa removed. The testa contains materials which darken on processing and storage. They have found no way to sterilize the coconut milk without causing a curd to form. However, while the curd is still warm they break it up by homogenization and a fluid milk is once again obtained. It is packaged in a bottle or in a plastic bag. They can do some post-heating but not too much because the product will curd again. A Thai company is reported to be interested in marketing this product. A patent has been applied for in Australia but not in Thailand because the latter does not enforce patent laws.

Dr. Wrenshall showed us several other products that are being developed by ASRC. One is a coconut honey made from coconut milk which was concentrated by evaporation and mixed with invert sugar. The consistency was

approximately that of honey and the product had a pleasant coconut flavor and aroma. We later saw a product like this on sale in Hawaii. Another product ASRC are working with is a coconut-soy beverage made from coconut milk and soy milk. They are also working with some snack items. One was a fried chip containing 16% protein which was made from a blend of soy isolate and tapioca which was mixed into a stiff dough, sliced and deep fat fried. This product had a very good flavor. Another product that they called "Bean Stalk" contained 18% protein. It was a fried mixture of sesame seed, sesame flour, defatted rice bran flour, wheat flour and mung bean flour.

Dr. Wrenshall said that soybeans are produced in and exported from Thailand. One use of soybeans is in tofu, but for this purpose the Thais generally prefer mung beans which are 25% protein, low in fat and higher in starch. The production of mung beans is double that of soybeans. Some of the mung beans are exported to the United States for bean sprouts. Noodles are made commercially from mung bean starch and the protein is commonly discarded in this process. ASRC is interested in trying to increase the food use of soybeans in Thailand.

ASRC may conduct work for outside organizations. They did a survey for Archer-Daniels-Midland on the possibility of marketing a textured vegetable protein in Thailand. In addition, ASRC is presently interested in the possibility of solvent extraction of rice bran and the solvent milling of rice.

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INSTITUTE OF FOOD RESEARCH AND PRODUCT DEVELOPMENT October 30, 1969
Kasetsart University
P. O. Box 4-170
Bangkok, Thailand

Dr. Amara Bhumiratana, Director of Institute

Dr. Insee Chandrastitya, Governor of the Applied Science Research Corporation
Dr. Mike McGarry

Dr. Amara had a luncheon served for us at the Institute. In it were included several recipes with which his Institute is working. These included:

(a) a mixture of soy protein curds with other ingredients that were spread on bread and then toasted;

(b) a cabbage roll which included soy protein and peanuts among its ingredients;

(c) rice with a curry made from coconuts.

Dr. Amara has been developing a canned concentrated coconut milk. The milk is made by grating coconut on a spiked roll and pressing the gratings in a small homemade screw press. The press was constructed of brass and the cage had round holes about 3/32 inches in diameter. The milk is concentrated in a thin film evaporator and packaged in lacquered cans. It was reported to be stable for at least two years. Only pared coconuts were used with added sodium bisulfite to prevent browning. The concentrated coconut milk contains about 13% moisture and 70% oil. Dr. Amara was not optimistic about the possibilities of commercial success with this product because of the high cost of production and the unavailability of high quality tin plate in Thailand.

Dr. McGarry is a Canadian who was working at the Asian Institute of Technology at Kasetsart University. He was doing research on the growth of algae on sewage. He had had previous experience in this type of research in Australia and in California. He made the comment that in California there is a plant producing algae whose entire production is being purchased by a manufacturer of adhesives. While we have made no effort to investigate this

report for further details, it does represent an example of determining the useful functional properties of a protein and putting these properties to work.

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USAID/MANILA
Philippines

November 3, 1969

Mr. T. C. Niblock, Deputy Director
Mr. Philip W. Ruppert, Manager, Office of
Industrial Development

Mr. Niblock had only recently arrived to take up his new position in Manila. He indicated a considerable interest in the survey we were conducting. Mr. Niblock said that he would like our report to contain our overall observations on the coconut industry, its problems and both the scientific and economic research that is needed.

Mr. Ruppert contributed generously of his time, helped us in setting up useful appointments and provided us with a substantial amount of background information and material. The AID/Philippines goal is a means for getting coconut proteins into the diet of Filipinos while still producing good quality oil in yields adequate to maintain the income of the coconut industry.

Only about 7% of the coconuts produced in the Philippines are consumed as food. One and one-half million tons of copra are produced annually which yields about 500,000 tons of copra cake containing around 20% protein. About 40% of the copra is pressed in the Philippines and the remainder is exported. The long-range trend has been toward more of the copra being pressed in the Philippines. The oil mills are owned privately. New mills that are constructed are of the screw press type because they are less expensive. The LuDo and LuYm Corporation operates the only prepress solvent plant in the Philippines at Cebu City. In this plant, the coconut is shredded and pressed

to a residual oil content of about 18% and the cake is then solvent extracted. This plant produced 44% of the total exports of copra meal in 1965.

Mr. Ruppert stated that the new processes that have been tried in the Philippines for the production of food grade protein products from coconuts have failed for the following reasons:

(a) the size of the operation was too small;

(b) the plants and processes were uneconomic;

(c) there was not enough or no premium for the higher quality oil produced;

(d) there was no demand for coconut milk;

(e) there were too many intermediate products that had no value.

It has been reported that independent investors named Ramos are installing a Carver Greenfield in the Philippines but Mr. Ruppert did not have any of the details. It was rumored that the equipment was already in the Philippines. The basic component of the Carver Greenfield process is a falling film evaporator which operates at low temperature and under vacuum. In the total process, coconut meats are homogenized along with added coconut oil using appropriate grinding to rupture the oil cells.

This puree of oil and solids is passed through a falling film evaporator and then centrifuged to remove part of the oil. The residue from the centrifuge contains 65% oil. This residue is extracted by solvent to produce an oil and a flour,the latter containing all of the fiber originally present in the coconut meats.

The Carver Greenfield falling film evaporator has been very successful in orange juice concentration. The V. D. Anderson Company in Cleveland, Ohio

has installed a Carver Greenfield pilot plant. It is not known whether this pilot plant has as yet processed any coconuts. Mr. Ruppert indicated that the minimum size economic unit was estimated to be 50 tons of dry coconut meats per day.

According to Mr. Ruppert, the major foods consumed by Filipinos are rice, vegetables, dried fish and a fish sauce that is used for flavor. Their consumption of bread and milk is limited. While an imitation milk based on coconut proteins might be an approach to improving the diet of the Filipinos, this would be contingent upon developing an acceptability for the milk. The Filipinos do like sweet drinks. They produce some mungo beans which are used primarily to make noodles.

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NATIONAL SCIENCE DEVELOPMENT BOARD
95 East Rodriguez Street
Quezon, Manila
Philippines

November 3, 1969

Dr. Juan Salcedo, Jr., Chairman

We met briefly with Dr. Salcedo to explain our mission. He was most interested and offered the fullest cooperation of his organization. The NSDB is a government agency consisting of a number of commissions or institutes which include the following:

National Institute of Science and Technology (NIST)

Philippine Atomic Energy Commission

Philippine Investors Commission

Philippine Coconut Research Institute

Philippine Textile Research Institute

Forestry and Forest Products

NATIONAL INSTITUTE OF SCIENCE AND TECHNOLOGY
Herran Street, Manila
Phillippines

November 3, 1969

Dr. Jose R. Velasco, Commissioner
Dr. Flaviano M. Yenko, Deputy Commissioner

The National Institute of Science and Technology is divided into ten or more research centers. We later visited several of these. Attempts have been made to produce concentrated canned coconut milk but the project has been deterred by the expense of the cans and the darkening of the products due to iron in the process equipment. Dr. Velasco said that two deterrents to greater utilization of coconut as food are the indigestibility of the fiber and the laxative effect resulting from eating large quantities of coconut oil. The Subramanian acid or alkali pre-treatment of coconut meats for copra manufacture has not been adopted because the treated copra resulted in no greater economic return to compensate for the added expense. In fact, Dr. Velasco suspects that deteriorated copra may be preferred by many buyers because the oil content is higher. Further, the acid treated copra was found to be corrosive to handling and processing machinery.

Dr. Velasco believed that research is needed to correct the disadvantages of coconut oil, of coconut protein, the oxidation of copra meats and to achieve a separation of fiber from protein in coconut flour.

Peanuts are an important Philippine crop and the nuts are eaten either roasted or boiled. There is a rather high rate of liver cancer in the Philippines which may be caused by the aflatoxin in the peanuts.

Copra, mahogany lumber and hemp are the three major Filipino exports. Copra is first but lumber is moving up rapidly.

FOOD AND NUTRITION RESEARCH CENTER (NIST) November 5, 1969
Herran Street, Manila
Philippines

Dr. Conrado R. Pascual, Director
Mrs. Estelita M. Payuma, Chief, Food Technology Branch
Mrs. Olympia N. Gonzalez
Mr. Alfredo C. Guerrero

The FNRC has conducted nutrition surveys which were reported in the Philippine Journal of Nutrition, Volume 22, April-June, 1969. These surveys showed that the average caloric consumption in the Philippines was 1762 calories per day which Dr. Pascual considers to be about 86% of minimum requirements. The protein consumption was estimated to be 92% of the recommended minimum amount of 1 gram of protein per kilogram of body weight per day. Fat consumption is also low in the Philippines.

The FNRC has set up 207 nutrition councils throughout the Philippines at the local level. The objectives of these councils are:

1. nutrition education;
2. home food production;
3. feeding of preschool children;
4. training.

Through these nutrition councils, Dr. Pascual hopes to try to inform the people of the various areas about the status of nutrition in those areas.

Dr. Pascual was particularly concerned about the fact that 50% of the Filipino children are malnourished. He said that the reasons for malnutrition in the order of importance were:

1. lack of availability of proper foods in the markets;
2. lack of adequate income to purchase the foods;
3. and lack of knowledge about what foods are needed for good health.

Dr. Pascual is interested in the development of low cost protein foods for dietary improvement. For this purpose, he is most anxious to see a breakthrough in the economic production of a coconut protein isolate. He referred to the research of Dr. Emett Bolt who had tested coconut protein isolate and found it to be very nutritious. On the other hand, Dr. Pascual said that nutritional results with coconut flour have not been very satisfactory.

The PNRC have made some coconut protein isolates on a laboratory basis. Their objective has been to produce a bland isolate. For this purpose they have grated fresh coconuts with an equal amount of water and have pressed out the coconut milk. Coconut water may be used as part of the added water. The milk is centrifuged to produce cream, skim milk and a small amount of insoluble solids. The cream contains one-third of the protein and the remainder is in the skim milk. The skim milk is heated to coagulate the protein which is then separated from the whey. They prefer a heat coagulated protein to an acid precipitated because of the acidic flavor of the latter and the fact that the neutralized product has been somewhat darker than desired.

They have made a chocolate flavored beverage from this isolate. The beverage is made in a kitchen blender from a combination of the coagulated protein, some coconut oil, whey from the skimming of the cream and added chocolate flavor. The product has been formulated to have a 3½% protein composition. This chocolate beverage retained an undercurrent of coconut flavor which they believe would be fully acceptable. Dr. Pascual does not consider that this drink has a very promising future because of the present high cost of producing the protein isolate.

If water is not added during the grating of the coconut, the cream will not separate from the skim milk. The FNRC people feel that coconut cream is popular with Filipinos and probably could be a marketable product. They have found that the cream emulsion tends to separate so they have added sodium caseinate as an emulsion stabilizer.

We tasted some very acceptable cookies which contained 20% of coconut flour and 20% of coconut paring flour. Both flours had been produced by the Franklin Baker Company by screw pressing dried parings and desiccated coconut.

The FNRC has developed two weaning foods which look very interesting. One is a therapeutic product and contains 38% protein. It is made from coconut protein isolate, mung bean flour, rice flour with 5% fish protein concentrate added to provide amino acid balance. The other would be a staple weaning food containing 25% protein. It is made from a blend of coconut skim milk, mung bean flour, rice flour and 5% fish protein concentrate. The samples we saw had an attractive appearance and odor. They looked very much like high quality infant foods produced in the United States. These products had been produced on a small drum drier in the Industrial Research Center of the NIST. The products had been approved by a taste panel but had not yet been nutritionally tested. Dr. Pascual said that there were two Filipino companies who have shown some interest in these products.

The original work on the Subramanian acid or alkali dip process for copra was done at the Food and Nutrition Research Center. Alkali was considered to be preferred to acid for both practical and economic reasons. Dr. Pascual believes that some of the larger processors are using the alkali dip process because it makes it possible for them to hold the copra longer at a lower

moisture content so that they can sell under the most favorable market conditions. Copra is priced on the basis of moisture content with the lower moisture product bringing higher prices. The exporters may receive a higher value for copra with a lower free fatty acid but it is possible that this price advantage is not reflected in the price paid to the farmer. The inequities in copra pricing at the various exchange points in the marketing process may be what has prevented a more widespread adoption of the Subramanian procedure.

Although efforts are being made to introduce soybeans into the Philippines, Dr. Pascual does not look upon soybeans as the solution to the nutritional needs of his country. This is because of economic problems and because the soy is not a familiar item in the Philippines.

* * *

INDUSTRIAL RESEARCH CENTER (RIST)
Herran Street, Manila
Philippines

November 6, 1969

Mr. Felipe L. Santillan, Director
Mr. Conrado E. Lotho, Assistant Director
Mr. Pedro C. Catanaoan, Jr.
Mr. Palridel H. Recado
Mr. Guillermina C. Manallac

The IRC people stated that coconut protein denatures at temperatures above 90°C. They believed that the material temperature in the Proctor-Schwartz drier at the Franklin Baker Company in Davao is about 105 to 110°C. This is about the same temperature attained in the fluidized bed drier with which they have been experimenting, but they feel that the latter has the advantage of a shorter retention time. However, they have had difficulty preparing satisfactory products with the fluidized bed drier. The rejects have been caused by wet

feed material sticking to the perforated screen in the bottom of the drier. This material scorches to a brown or black and causes specks in the finished product. They believe that they can solve this problem by replacing the screen with one made of teflon.

Mr. Lotho said that a two person team of a sheller and a parer can process about 1000 coconuts in an eight hour day.

The IRC is now working on a wet coconut process which they call the "RIST Improved Coconut Meats Process". It is similar in many respects to the Tropical Products Institute process. Coconut meats are milled with coconut water and pressed in an expeller to produce coconut milk and a press cake. The milk is centrifuged in a basket centrifuge to separate the solids which came through the press screen. It is then centrifuged to three product streams: a cream, a skimmed milk and a protein solids. The combined skim milk and protein solids are then either drum or spray dried. The cream from the centrifuge is heated to break the emulsion and to precipitate any protein. This is then centrifuged to separate the protein from the coconut oil. The solids from the dewatering press are dried and solvent extracted to produce oil and a high fiber meal. We inquired about the material balance on the process and analyses of the products and were told by Mr. Recado that he would send us this information. It has not yet been received. We were given samples of the drum dried protein. (The two samples differed substantially. One had a light color and a pleasant odor; the other had a scorched color and odor. Our analysis indicated that the lighter sample contained 20% protein which had only been slightly denatured as measured by its pH-solubility profile. The scorched sample contained 30% protein whose solubility was intermediate between that of

an undenatured product and a screw pressed meal. While this would not suggest any reduction in nutritive value, it would be expected that this sample would have its functional properties substantially altered.)

The processing pilot plant of the Industrial Research Center was rather impressively supplied with equipment. Much of it was good equipment made of stainless steel. The best looking was that received from Japan as reparation payments. They have a German colloid mill and a single disc attrition mill of Philippine manufacture. At the present, the IRC staff do not seem to have a preferred method for grinding their coconuts. They have been dewatering the milled coconut meats in a Japanese made screw press. They are presently constructing in their own shop a one-pair high dewatering roll which operates like an old fashioned laundry wringer. They said that preliminary experiments have indicated that this method of dewatering will be quite effective with milled coconut meats. Among other equipment observed were:

Several stainless steel jacketed tanks with agitators

Three disc-bowl liquid-liquid centrifuges

A horizontal spray drier

A milk evaporator with a coil type heater

A small Buflovac vacuum drum drier

A larger atmospheric drum drier

A pressure or vacuum double arm mixer of about 1 cubic foot capacity

Several basket centrifuges of different sizes, the largest having a bowl about 2½ feet in diameter

An oil hydrogenating and deodorizing facility

BIOLOGICAL RESEARCH CENTER (NIST)
Herran Street, Manila
Philippines

November 6, 1969

Mrs. Luz Banes-Arcega, Director
Mr. Macario Palo
Mrs. Dolores Hipolito
Dr. Clare Baltazar

The program of the Biological Research Center is microbiologically oriented. They have worked with coconut water, copra meal, coconut husks and coconut flour. The research they discussed with us was mostly based on coconut water. They have produced a 50% protein concentrate by growing strawberry yeast on coconut water with added nutrient salts. They said that mushroom mycellium will also grow well on coconut water and the product will contain 50% protein. They have also produced vinegar from a mixture of coconut water and sugar. The product that appeared to be most interesting was nata de coco. This is a polysaccharide gel with properties somewhat like gelatin but stiffer and which does not disintegrate when warm. Nata de coco is presently used as a dessert in the Philippines and is being exported to Japan. It is produced by growing acetobacter on a medium containing coconut water, 10% sugar and ammonium phosphate. While this acetobacter will grow on sugar water alone, it was said that coconut water contains some unidentified growth factors which result in better production. (This is one of several references we heard to unidentified growth factors in coconut water. At no time were we able to find any solid scientific confirmation of the existence of such growth factors.) Nata de coco is commonly used in the homes and is presently made in small industries. NIST provides the microorganisms for these industries. Mrs. Banes-Arcega said that the production of nata de coco is fast becoming a food industry. She said that the California Fruit Company (CPC International) is interested in nata de coco and Unilever has asked for samples of the microorganism.

The Biological Research Center has made some study of the solubilization of crude fiber in coconut flour but do not consider this to look too promising at this time. This is due to the slow rate of activity of the enzyme.

Dr. Baltazar showed charts illustrating the work of her group relating the composition of coconuts to their stage of development. The oil and protein content on the basis of yield per nut is highest at thirteen months. These values are nearly on a plateau between 12 and 14 months.

* * *

FRANKLIN BAKER COMPANY
Davao, Mindanao
Philippines

November 4, 1969

Mr. A. C. Maceda, Jr., Plant Manager
Mr. Peregrino H. Quinitio, Manager of Research and Quality Control

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This plant produces desiccated coconut for export to the United States. The husked coconuts are brought to the plant by truck from the farms and are unloaded into a housed storage bin. The current price of coconuts is posted clearly at the entrance of the plant. On the day of our visit, the price was 148 pesos per metric ton. Immature, overmature and cracked nuts are segrated during the unloading and are put back into the truck and deducted from the net weight. Farmers then make copra from these nuts. The percentage of rejects runs between 1 to 7%. The major problem in Mindanao is overmaturity. Many farmers harvest only every three months so that many of the nuts are overmature resulting in a loss of yield in the desiccating operation. In Luzon on the other hand, they are starting to have a problem of receiving undermature nuts as the farmers have learned that these weigh more per nut. In Luzon, the supply of nuts is irregular due to wet and dry seasons. In Mindanao, the rain is spread

out over the year more evenly so that the supply of nuts to the desiccating plant is more constant.

From the storage bin, nuts are loaded by hand onto a conveyor belt to the process section. At this point, any previously overlooked undesirable nuts are culled out. The nuts are shelled and pared by hand. A team of two works together, one shelling and the other paring. The sheller uses a small hand tool that looks like a hatchet on one face and a pry on the other. The parer uses a hand device similar to a potato peeler. For maximum output, the team will switch jobs periodically. The parings appear to be approximately 1/16 inch thick.

The pared nuts go through breakers into a surge bin from where they move onto a large inclined screw elevator where they are washed with water. The washed pieces then go to shredding devices manufactured by Bauer Brothers and which appear to be attrition mills. The shredded coconut drops immediately onto a traveling screen of a Proctor and Schwartz drier.

The maximum temperature of drying air was said to be 240°F. We did not learn the actual temperature of the product going through the drier. (Because the product from the drier shows no indications of a browning reaction, it is a fairly safe presumption that the protein has suffered very little or no denaturation. The drying is by steam heat produced by burning coconut shells. The Davao plant does not use its entire supply of shells for this purpose. However, a plant near Manila has to burn a little fuel along with the shells in order to provide the necessary amount of steam.

From the drier, the shredded coconut is screened into several grades and packed into one hundred pound paper bags. At this point, the dried coconut contains about 3% moisture. We were told that the entire process from the whole coconut to the desiccated coconut in bags requires about one hour.

The coconut water is discarded. Because it is corrosive, the area around the paring and shelling operations was constructed of wood.

The parings are dried in a separate drier and are shipped to another plant where they are screw pressed into oil and paring meal. Paring meal was reported to contain 12% fiber, 12% oil and 18 to 20% protein.

The minimum agricultural wage in the Philippines was said to be four pesos per eight hour day. The workers at the Franklin Baker plant received six pesos per day as a minimum and on a piece work system could earn as much as seven to eight pesos.

The Franklin Baker Company were using extensive precautions to avoid bacterial contamination of their desiccated coconut. They said that the plant was washed down every shift with water containing a bactericide. Only authorized personnel are permitted in the drying area. Before entering, these persons must wash carefully, put on clean smocks and caps and walk across mats soaked in disinfectant.

* * *

USAID/PHILIPPINES
Manila

November 7, 1969

Dr. R. W. Engel

Dr. Engel is the Associate Dean of Research of the College of Agriculture at Virginia Polytechnic Institute, Blacksburg, Virginia who at the time of our visit was a Special Assistant on the War on Hunger to the Philippine Mission. The following are comments made by Dr. Engel.

The Del Monte Company on Mindanao are growing soybeans for about 1000 head of cattle that they have on their plantation. He said that this is done

because the copra cake available in that area is of such low quality. Both Del Monte and Dole have pineapple plantations on Mindanao. Del Monte is not too pleased with the yields they are getting with their soybeans. The Philippine Bureau of Plant Industry is doing breeding work on soybeans.

Dr. Engel is experimenting with the use of coconut paring flour in infant foods. Although this flour contains 11 to 12% fiber, he considers the high fiber no detriment if it is ground finely enough. He is presently feeding seven nursing infants a mixture of coconut paring flour and mungo bean flour.

Dr. Engel said Mr. Quinitio of the Franklin Baker Company had told him that Baker is interested in manufacturing new food products and that they can make mungo flour. The mungo bean has a substantial proportion of lysine which could supplement the rice that is common in the Filipino diet. However, cost is a problem because mungo beans currently sell for 1.5 pesos per kilogram. He said that the Baker Company was producing a coconut flour by screw pressing desiccated coconut which is presently in surplus.

The three companies in the Philippines that have the best marketing organizations are the San Miguel Company (beer and coca cola), the Del Monte Company and the United Drug Company. While these companies may be able to introduce new foods into the Philippines, Dr. Engel believes that none of them reaches the lowest income groups at the present time. United Drug is interested in marketing a weaning food along with a vitamin supplement which they have been selling at a considerable profit for a long time. This vitamin preparation is supposed to combat nutritional deficiencies particularly in pregnant and lactating women.

Dr. Engel said that a large percentage of the coconut palms in the Philippines are on hilly ground unsuited for other agriculture. This could

make accumulation of fresh coconuts for processing somewhat difficult. He believes that it is a situation more suited to copra production.

* * *

KANEGAFUCHI CHEMICAL INDUSTRIES COMPANY, LTD. November 11, 1969
Osaka
Japan

T. Takada, Executive Director
Y. Ishisaka, Planning Division (Interpreter)
E. Harada, Director, Chemical and Fermentation Division
Nobuo Mogi, Director, Research and Development Division

This company is reported to be building a plant to produce 120,000 tons per year of yeast containing 60% protein. The nutrient medium will be normal paraffins. They intend to sell this first as an animal feed. They believe that their cost will make them competitive with other protein supplements which must be imported.

For food applications, they are working with a food company. To avoid any concern about toxicity due to hydrocarbons, their plan is to make protein isolates only for use in foods. They said that the procedure they are using should not denature the protein. They said that it is a difficult isolation and is being done by the food company.

Kanegafuchi is looking forward to an export market among the Pacific islands and along the East Asian coast. However, in their judgement, before they could export any petro-protein as a food they feel that they must have the approval of the U. S. Food and Drug Administration. They say that the U. S. FDA is looked upon as the standard.

Mr. Takada said that they expected to have some isolate by January or February of 1970 and agreed to send us some. They divulged no details of

their processes. However, in considering the potential usefulness of proteins from coconuts, we feel that it is important to be aware of the merits of all potentially competitive products.

Summary, Conclusions and Recommendations

The objective of this survey was to determine the state of the art in the processing of fresh coconuts for food use. Before we embarked on the journey, we read a number of documents received from a variety of sources which discussed new and improved processes for making a variety of coconut protein food products. In several instances, it was reported that plants had been built and were operating based on some of these processes. We could find no evidence that any such plants are in oparation at this time. As far as we could find, all of the processes that have been reported in the literature, with one exception, have been abandoned, even by their initial proponents. The exception is that of the Franklin Baker Company who do have the capability of drying coconut meats and expelling part of the oil to recover a press cake that can be converted into a coconut flour. However, we found no evidence that they have developed a market for this type of coconut flour.

There is still considerable research activity on coconuts, which can be divided into product research and process research. A major area of product research is that of making a more economical and convenient coconut milk. Coconut milk is used extensively in several countries for making curries. Presently, most of the coconut milk is made in the home by a tedious process that is wasteful both of oil and protein. Efforts to commercialize the production of coconut milk either as a whole milk, concentrate or cream should be encouraged. It is estimated that by commercializing the operation, the recovery of nutrients per nut could be approximately doubled. This could be extremely important in countries where proteins and calories are both deficient. There is adequate know-how available to make these products. What is now needed is a marketing

effort. It is recommended that national and international agencies concerned with food and nutrition find means for encouraging the manufacture and sale of coconut milk products in those countries where it is presently popular. For reasons that will be explained later, we do not recommend an effort be made to encourage the use of coconut milk in those countries where it is not now popular.

Another product that may have good potential is coconut honey, which is made from coconut milk and invert sugar. It is a very tasty product that is used like we use honey in the United States. While it might not be considered to be an important nutritive supplement in a tropical country, it conceivably could become an important item for foreign exchange. It is very possible that a good marketing company could develop this into a substantial export business. Here again, the research has been done and what is now needed is market development.

Weaning foods are under consideration in several groups. One of these is experimenting with an expeller coconut flour and if successful could have an available source of supply. The others depend upon coconut milk or coconut protein isolate as a protein supplement, and therefore could not become marketable until these ingredients are available. The same is true of a chocolate coconut protein drink which is based upon a coconut protein isolate. Both a weaning food and an attractive beverage could be important dietary supplements in any of the coconut producing countries. However, one must first devise a means for the economic recovery of the coconut protein.

This, of course, is the objective of the process research which is presently underway. In our judgement, the process most likely to be commercially successful, of those presently under investigation, is that of the Tropical

Products Institute in London. This is a wet process of fresh coconuts which depends upon centrifugal separation into three product streams: oil, protein and water solubles. Because of a troublesome fourth phase which is an emulsion containing both oil and protein, their process is not now economically feasible, as they are recovering only about 85% of the available oil. TPI feels that a breakthrough from this point is more likely to come from basic research on the physical chemistry of the emulsion than it is from traditional process research.

This point of oil recovery bears close scrutiny. It is the real key to any viable process for producing coconut proteins. It is one of the key factors causing the other processes that have been investigated to fail. One must look at the current uses for coconuts in order to see any proposed process in a proper perspective.

In the producing countries, coconuts are used for two purposes: food and copra. Perhaps some of the investigators in the past have been misled by looking too hard at the food uses and ignoring the economics of the copra process. The food uses have been and still are very primitive. In the main, the coconut kernel is scraped out of the shell by hand and squeezed to recover coconut milk. The residue is discarded. The coconut milk probably, on average, represents less than half of the available nutrients in the coconut. It is easy to devise a commercial process that is superior to this and in those countries where coconut milk is used in large quantities, it is our opinion as expressed earlier that a commercially produced coconut milk could become a successful product.

However, the economics of this are not as simple and straightforward as they might seem to be on first glance. The immediate assumption is that

the processor would probably pay about the same price for the coconuts as does the home user. This may or may not be true. One would have to determine where and how the people buy their coconuts and how much they pay for them. It may be that many or most of them have their own coconut tree and never really enter the cash market. It would require some special kind of marketing arrangement to acquire these people as customers. Nonetheless, the basic idea is sound so it should be possible ultimately to overcome whatever marketing problems arise.

However, for any new manufacturing facility the copra industry would be the primary competitor for coconuts. The copra industry is rather deceptive. Superficially it looks rather primitive. Actually, it is quite efficient for what it is trying to do. The objective of the copra industry is to produce coconut oil and copra meal at the least possible cost. One would be hard pressed to try to devise a system that is more economical than that now in use. The coconuts are dried at or near the point of production. The cost of drying is absolutely minimal. They are dried either by the sun or in simple, inexpensive kilns heated by burning coconut shells. Consequently, there is no excess weight shipped from the producing areas to the manufacturing or export centers. The relatively inexpensive expellers which are in common use recover 94 to 95% of the available oil, and there are only two product streams both of which enjoy established markets. It is generally recognized that the production of copra is unsanitary and that copra is often infested with insects and mold. However, this does not appear to have seriously affected either the market or the price for coconut oil and coconut meal.

The other important consideration about copra is that for many of the countries it represents a very important component of their foreign exchange.

Exportable items very properly have high priorities in the governments of developing countries. Any process that would reduce significantly the value of exports would not be very popular. Therefore, if a process for the recovery of coconut protein only recovers 85% of the available coconut oil, this would reduce the amount of exportable coconut oil by 10%.

To look at it from another perspective, at an 85% oil recovery each pound of protein produced would have to bear a burden of about 10¢ for the loss in oil value alone, over and above the cost of the meal and any additional costs in processing. It is because of these considerations that we would not recommend an attempted introduction of traditional coconut milk in those countries where it is not now extensively used. Even commercially produced coconut milk, although having a competitive advantage over home produced milk, would be a substantially less efficient operation than copra processing. Most of the now-abandoned processes started with coconut milk, and ended in a maze of product streams and too-high product costs.

It is our recommendation, therefore, that any further process research for the recovery of proteins from coconuts be guided by the following criteria, in the order named:

1. Economic feasibility: Probably the most important factor is an adequate recovery of the oil. One cannot overemphasize this point. For every pound of protein recovered, there will have been seven pounds of coconut oil in the process. Economically, the oil totally dominates. Any process that ignores this could be pre-doomed to failure. Other factors to be considered under this criterion are proper sizing and location of plants.

2. Profitable disposability of all of the product streams: This has been a major pitfall of most of the processes that have been abandoned

and that are presently under investigation. While they have concentrated their attention upon one product stream, they have created four or five other streams for which markets would have to have been developed. Ideally, a process for coconuts should yield no more than four product streams: oil, protein, fiber and water solubles. A market exists for the oil and it is presumed that markets can be developed for the protein. The fiber and water solubles are unavoidable by-products for which a home would have to be found.

3. Technological feasibility: Based on the accumulated judgement of the many people with whom we talked, there appear to be three processes that should be considered as means for producing food proteins from coconuts. The first of these is to screw press or to prepress solvent extract desiccated coconut. The major advantage of this approach is that plants already exist in which such operations could be carried out. The major disadvantage may be the limited potential food applications of the protein products. The second process would be to prepare coconut meal by traditional solvent extraction procedures, and then look for food applications for coconut flour, coconut protein concentrates and coconut protein isolates made from that meal. The third process would be a modification of the centrifugal system used by the Tropical Products Institute. If successful, this process would have a number of advantages that make its greater technical challenge worth undertaking.

All three of the above processes have the capacity to meet the first two criteria. In our judgement, all three are also potentially feasible from a technological point of view.

4. Market potential of the product streams: Although this should be inherent in the second criterion, it is sufficiently important to

establish as an independent criterion. Each of the protein products developed by any process under investigation should be thoroughly evaluated for its highest and best potential use. It is not sufficient simply to try to do with coconut protein the same things that have been done with soybean protein. Rather, it would be important to determine those uses for which coconut protein products are uniquely useful. This should maximize both their consumption and their economic return to the producers and the processors.

5. Nutritional value: It has been traditional among protein research groups to give nutritional value the top priority. This has led to the expenditure of large sums of research effort on nutritious formulas which have not been able to meet the challenge of the market place. We believe that it is reasonable to start with the premise that coconut protein has been demonstrated to be nutritious, and that processing technologists have become sufficiently sophisticated that they know fairly well what not to do to avoid destroying a protein's inherent nutritional value. We believe that in the processes outlined above, most of the inherent nutritional quality would be retained except for some disproportionation of amino acids that might occur during the isolation procedures (similar to that which occurs during the isolation of soy protein). We do however believe that nutritional value should be a final criterion when food product prototypes have been developed.

General Comments

There are some comments not directly related to the specific objectives of this survey that we think worth recording. We found a number of competent people doing research on coconuts. To a large degree, their research

suffers from several deficiencies:

1. Lack of well thought out priorities;
2. Lack of clear and positive direction;
3. Very little contact with industry;
4. No apparent means to follow through on a product idea.

We became impressed with the fact that the coconut industry is so largely dependent upon a market for coconut oil. Therefore, the internal economy and foreign exchange position of some of the countries we visited depend in very great measure on coconut oil. We suggest therefore that attention should be directed toward the future market potential of coconut oil. In this instance, historical trends could be misleading. Scientific developments of the past decade could exert a major influence on the future markets for coconut oil. It would seem mandatory that people who are concerned about the economies of the coconut producing countries should make a carefully planned survey to determine what the market for coconut oil is going to be ten years or twenty years from now.

Some thought should also be given to an optimum agricultural mix for the coconut producing countries. For example, while we have read reports indicating a substantial amount of intercropping in the Philippines, this certainly was not confirmed by our personal observations. However, our observations were not an investigation and could have been totally nonrepresentative. Evidently, at least one progressive plantation near Davao has decided that coconuts do not represent the best use of their land. We saw young bearing coconut trees being bulldozed out of the way to make room for banana plantations. Dole and Del Monte have both established pineapple plantations in the Philippines. This

will certainly improve the export-import balance. It is possible that there are other crops that might be more useful and profitable than coconuts. It seems that the coconut producing countries should want to have a careful study made of this possibility.

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Overseas Trip Report

Stanley P. Clark and Karl F. Mattil

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During the latter part of October and early November, 1969, Mr. Stanley P. Clark and Dr. Karl F. Mattil made a reconnaissance survey of research pertaining to or related to the utilization of fresh coconuts in the production of food products. The purpose of the survey was to determine the status of research efforts that were known to have been conducted as well as those that were presently underway.

Advice from a number of sources guided us to centers of coconut research in England, India, Ceylon, Thailand and the Philippines. On the advice of Dr. Ragnar Ohlson, Vice President of Research, Karlshamn, we visited the Biochemical Institute at the University of Uppsala and the Alfa-Laval Company in Tumba, both in Sweden. The food industry in Sweden has encouraged the Biochemical Institute to undertake an investigation of the food use potential of rapeseed, a project which parallels in many ways the Texas A&M project with coconuts, and Alfa-Laval is very interested (in both rapeseed and coconut processing).

Because single cell proteins do represent a potential competitor to coconut or any other unconventional proteins, and because it was believed that the industries involved, not being established protein companies, might be using some fresh, non-traditional approaches that, if divulged, could be useful, we contacted three companies who are in the forefront in SCP, two in England and one in Japan.

The first section of the report is a chronological record of the information and impressions we received from our many conversations. While we

have tried to record and report as accurately as possible, if we did misinterpret or misunderstand any of the persons with whom we talked, we apologize.

The second section of the report summarizes our impressions, conclusions and recommendations.

We express our sincere appreciation to the many people who helped us plan this survey, and those who spent many hours telling us about their work and answering our questions, and particularly to Mr. Philip W. Ruppert, USAID/Philippines, for much assistance and down-to-earth commentary.

THE BRITISH PETROLEUM COMPANY, LIMITED
Britannic House
Moor Lane
London, E.C.2, England

October 13, 1969

Mr. Gordon H. Evans, Research Co-ordinator
Research and Technical Development Department
Mr. D. L. Knights

British Petroleum is working on two processes from different petroleum feedstocks to produce yeast containing about 65% protein. One process uses a straight-chain paraffin feedstock and the product does not require solvent extraction of residual paraffin. The other process uses a relatively heavy gas-oil fraction from refinery by-products and requires solvent extraction to remove the petroleum residue. The most information on British Petroleum processes for yeast production from petroleum are contained in an article in Hydrocarbon Processing for March, 1969. This publication has considerable information on their processes, but no secrets are divulged. Other references on the subject are Chemical Week for August 2, 1969, and Chemical Engineering for August 26, 1968.

British Petroleum expects to be selling the products for animal feed next year. The economics of their process are such that they do not expect to be able to compete for animal feeds in the U. S. market. However, they do believe that they can compete in the British and European markets. In Britain, 44% soybean meal is sold at 50 pounds ($120.00) per long ton. Fish meal with 65% protein sells for 80 pounds (192.00) per long ton. They think that they can compete successfully against these prices.

A policy decision has been made by the top management of BP that for the present they will direct their attention exclusively toward the animal feed market. Consequently, they are doing essentially nothing about possible uses in foods. It was apparent that the management's decision has not prevented Mr.

Evans and Mr. Knight from thinking about food applications. Because of this, they are rather unhappy with the name "petro-protein". They feel that this could be a negative in the food industry. We suggested to them that if they created the image of their product as being an animal feed, the transition to food use would be somewhat handicapped. People would continue to think of it as an animal feed.

BP have made isolates from their petro-protein, and have run pH-solubility curves. They have also demonstrated on a laboratory scale that these isolates can be spun.

In designing their clean-up procedures, BP have used the Food & Drug Administration standards for FPC to evaluate their product. They believe that the protein they are now making meets all the requirements the FDA has established for FPC, and do not expect any problem with FDA approval unless FDA comes up with some new arbitrary position as they did with FPC. A strict interpretation of present food laws in the United Kingdom would prevent the use of petro-proteins under any circumstances. These laws state that no food shall contain anything that has been made from or which has included a petroleum product. BP seems to believe that this law can be changed.

Mr. Evans said that he will send us a sample of their product if he can get top management approval. This may not be given until after top management has decided to give active consideration to food applications.

The BP petro-protein has been rather extensively tested both in ruminants and in non-ruminants. One pig that was held as a reserve in a comparative feeding test had its ration adjusted to where it was including up to 65% of the petro-protein as the protein supplement. The pig grew well and no abnormalities were evident when the pig was slaughtered. A ham made from this pig was considered to have a normal taste.

RANKS HOVIS MCDOUGALL
Lord Rank Research Center
Lincoln Road
High Wycombe
Buckinghamshire, England

October 13, 1969

Professor P. Spicer
Dr. G. L. Solomons

Dr. Spicer has the title Professor as somewhat of an honorarium. There has been concern in England about the lack of communication between research people in universities and industry. To bridge this gap, universities have been giving academic appointments to selected scientists from industry. Dr. Solomons came to Ranks Hovis from British Petroleum two years ago and is conducting a fermentation research program.

This company is the largest food manufacturer in Britain. Their operations include freeze-drying of eggs, baking of bread, and milling of wheat. Dr. Solomons is in charge of work which is attempting to develop processes for the production of protein from various carbohydrate materials that are by-products of their milling processes. They are using fungi because they believe that the fungi have the least problem with nucleic acids and a built-in advantage due to the fibrous structure of the fungi.

Professor Spicer believes that it will be very difficult to produce food proteins using bacteria because these contain up to 12% of the nucleic acids. Yeasts are intermediate with 7-8% and fungi are lowest with 3-5%. Professor Spicer believes that the research done at MIT is convincing evidence that nucleic acids are biologically harmful. He said that British Petroleum has a process for reducing the nucleic acid content of their products using intracellular ribonuclease. This process was developed in cooperation with Dr. Steve Tannenbaum at MIT who has a patent assigned to the Sloan Institute.

Solomons believes that he can produce a 40% protein product using fungi at a cost of between 12 and 15 cents per pound. He says that the material has a naturally fibrous character which he believes will be compatible with some meat products. It has a nutty flavor that should be acceptable in some food systems. Professor Spicer indicated that if we should find an interest in using the waste fiber from coconut for fermentation, he would be willing to provide assistance to the program.

Of particular interest to us was a bread that Ranks Hovis is producing that was developed in their research organization. This bread is sold under the trade name "Nimble", and is sold as a diet food for weight control. It is a low density bread and each slice weighs substantially less than a normal slice of bread. Nonetheless, the bread has the appearance and texture of their ordinary white bread. This is made possible by blending native flour with partially denatured gluten. The denatured gluten retains its extensibility but is sufficiently denatured that it does not produce toughness. The native and denatured glutens are carefully blended to a formula that is 25% protein and produces a high quality loaf of bread under conditions of continuous dough manufacture. The process is a trade secret and is not patented. Professor Spicer says that Ranks Hovis has no plans to enter the international market with this bread. We examined and tasted a sample of the bread and found it to be fully comparable to the typical British bread. Obviously it is less dense than ordinary British bread.

Spicer has seen several plants in Russia where protein is being made from the cellulose of wood pulp by acid hydrolysis followed by fermentation. The proteins are being used for animal feeds. He believes that their processes are uneconomic, but that they do not have good enough cost accounting to know

what their costs really are. He does not consider the cellulases to be very promising at this time, as those presently in use are only effective on fairly pure substrates.

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TROPICAL PRODUCTS INSTITUTE
56/62 Gray's Inn Road
London W. C. 1, England
and
Culham Abingdon
Berkshire, England

October 15, 1969

October 16, 1969

Dr. David A. V. Dendy
Dr. Brian E. Grimwood
Mr. Winston Timains
Mr. A. W. James

Dr. Grimwood evidently is rather of a public relations officer in the organization and Dr. Dendy, who had been with them only about one year, directs their development laboratory and pilot plant. Mr. Timains is a process chemical engineer and Mr. James operates their research bakery.

Tropical Products Institute was founded 75 years ago as part of the British Ministry of Overseas Development. Its purpose is to help developing countries, both within and without the Commonwealth, to gain greater benefits from their plant and animal resources. It has five departments: Food Science and Technology, Non-foods, Economics, Industrial Technology, and Tropical Stored Products Center. It has a staff of about 350, more than a third of whom are scientists, engineers, and economists. The budget for 1969-70 is 795,000 pounds.

TPI has had an interest in the production and utilization of coconuts for quite some time. They have been working on processes for recovery of protein from fresh coconut for 5 or 6 years, but only in the past year have they had one chemical engineer assigned full-time to the project.

Dr. Dendy felt that there were three reasons why the processes that have been developed over the past 15 or 20 years have failed to become commercially viable:

(1) unfavorable economics

(2) bad siting of plants in areas where the supply of coconuts was inadequate

(3) lack of basic information for process optimization.

In their development work, they have used random coconuts as obtained, and have found that the maturity of the coconut has a substantial effect both on its processing characteristics and upon the nature of the products obtained therefrom. Dr. Grimwood commented that the agronomic conditions under which coconuts are grown undoubtedly influence their properties substantially. For example, he said that if coconuts are grown in a sulfur deficient soil the copra is rubbery and therefore is rather difficult to process.

TPI has developed a process for removing the coconut meats from the shell. They submerge the coconuts in water in a pressure tank and then build the pressure up to 50 or 100 pounds using air pressure (we were given these two different numbers by two different individuals). The coconuts are held at this pressure for about 60 minutes. Under these conditions, it is believed that the water is forced through the shell of the coconut and causes the coconut meat to shrink. The pressure is then released slowly over a period of about 20 minutes. If the pressure is released rapidly, the meats apparently expand and once again are difficult to separate from the shell. However, if the conditions are as prescribed, the shells will separate easily from the meats. They said that Goodrich Products of 137 Sierra Street, El Segunda, California, 90245 have developed a coconut sheller but they do not know how successful it has been.

TPI has developed, on a pilot plant scale, a process for making protein isolates from fresh coconut. If they remove the testa, the protein is white, but if the testa is left on, the protein is light brown. We were given samples of each of the two types of protein.

They believe that paring should be avoided if possible, because of the cost of this operation and also because the oil and protein in the paring end up in a copra-like product of lower economic value.

In the TPI process as presently developed, coconut meats are milled with an equal weight of room temperature water. The mixture is screened to separate fiber from an emulsion. The fiber is pressed to recover as much emulsion as possible. The emulsion is acidified to about pH 4. The acidified emulsion separates by gravity into four phases, namely: oil, oil-water emulsion containing protein, an aqueous layer containing carbohydrates in solution, and coagulated protein on the bottom. At present, the acidified emulsion is centrifuged, the protein sludge is collected and dried by ethanol or isopropanol. Along with the water, alcohol removes some of the oil which is carried over into the protein.

They have found the milling of the coconut meats to be an extremely important operation. Their objective is to put the cellulose into a condition that it can be separated from the emulsion using a shaking sieve. If the milling is not properly done, yields of oil and protein will be low and the separation will be difficult. In the pilot plant, we saw a stainless steel meat grinder of British manufacture which is reported to do a satisfactory milling job. It was said to be comprised of a wedge-shaped impeller which forces the material through holes about one millimeter in diameter. The operation is both cutting and extrusion. The closer the wedge is to the dieplate, the better the ex-

traction they get. They have tried a colloid mill, but found that it disintegrated the fiber to such a degree that it was difficult to separate from the emulsion by screening. The projected commercial process has milling in two stages, by a dicer and a crusher.

The screens used in the pilot plant are of the vibrating type like those manufactured by the SWECO Company. The screen is about 30 inches in diameter, of stainless steel. The one observed on the machine was 120 mesh, although 200 mesh was given as the usual size. By the procedure outlined, when using a 200 mesh screen, only a small amount of fiber is collected on a 300 mesh screen in series.

At present, the fiber from the screen is re-extracted with water to increase the yield of protein and oil. Single extraction with only a single stage is desirable and it is hoped that this will ultimately prove to be feasible The fiber contains nearly all of the oil lost, which amounts to 10% to 15% of the total, plus about 20% or more of the original protein. Work is being conducted on the development of a dewatering press to squeeze oil and emulsion from the fiber. Expeller pressing of the fiber has been tried in a Japanese "Hander" screw press. However, satisfactory expeller pressing requires drying of fiber, and this they do not want to do if it can be avoided. Processing of the fiber to achieve maximum oil and protein recovery, and to find a use for the fiber, is considered to be among their major problems.

The emulsion from which the cellulose has been removed is coagulated by acidulation to a pH of about 4. The acidified emulsion is then put through a three-phase centrifuge with a 6" disc bowl and at this point they encounter their most serious problem. Instead of three phases, they have four. The top phase is mostly oil and the bottom phase is mostly coagulated protein. The

second phase from the bottom is an aqueous layer which they said contains very little nitrogen. However, at the interface between the aqueous layer and the oil layer, there is an emulsion that contains both protein and oil. They have not been able to find a means yet for the effective recovery of oil and protein from this layer. Both Dr. Dendy and Mr. Winston Timmins, the chemical engineer who has been running the pilot plant, emphasized repeatedly that they would like to know more about the physical chemistry of the coconut emulsion system. They believe that there may be two different proteins that behave differently. They raised the question whether the material in the interface layer might be a lipoprotein. In their judgement, the separation and recovery of the oil and protein in this interface layer will be the key to a viable process.

Presently, TPI is washing traces of moisture and fat from their precipitated protein by extraction with ethanol at room temperature. The protein is then dried at ambient temperature. We raised the question whether this extraction was causing any denaturation and they did not know. As stated earlier, they have given us samples of their protein and we have agreed to run some functional tests of these proteins and supply them with the information we obtain. They were not making any functionality tests, and were quite interested in our approach. (We have looked at their two samples in a preliminary way. They contained 79% and 91% protein, but were substantially denatured as measured by pH-solubility profiles. Because of their low solubility, no further functionality tests will be made.)

The principle use they appear to have in mind for the coconut protein is as a supplement in bread. Mr. A. W. James, who is in charge of bakery research, has been experimenting with the use of cassava flour in blends with

wheat flour. He showed us some of the loaves of bread that he was baking and the cassava had a rather marked detrimental effect upon the texture of the bread. They have been using the coconut protein at a 3% level to bring the bread back to a normal protein content. The quality of the bread they were making with cassava (47%) and coconut protein (3%) was definitely substandard.

TPI may set up a coconut processing pilot plant either in Ceylon or in Barbados. We suggested to Dr. Dendy that it could be useful for us to collaborate in the development of processes for fresh coconuts. He appeared to be receptive to the suggestion. We asked whether he would be agreeable to having somebody from our staff spend a couple of weeks in his pilot plant and he promptly agreed. We feel that this is a very important contact and that we should maintain a constant flow of communications with Dr. Dendy.

Grimwood and Dendy mentioned that they understand that work on coconut is being done at Stanford University. A pilot plant is rumored to be under construction on the island of Samoa by an American firm.

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INSTITUTE OF BIOCHEMISTRY
University of Uppsala
Uppsala, Sweden

October 17, 1969

Biochemistry Institute:
- Professor Jerker Porath
- Dr. S. A. Lieden
- Dr. J. C. Janson
- Dr. Von Hofsten (Biochemistry Institute)
- Dr. Von Hofsten (Institute of Biology)

Also Present:
- Dr. Ragnar Ohlson, Karlsham
- Mr. K. Gillis Een, Alfa-Laval
- Mr. Reino Sepp, Alfa-Laval

After a tour of the laboratory, Professor Porath's staff presented a seminar on their work with rapeseed. This work was undertaken in large part at the instigation of segments of the food industry, as represented by Dr. Ohlson. Alfa-Laval are deeply interested because they believe that centrifugal approaches (such as at TPI) have substantial potential (Alfa-Laval makes centrifuges). The seminar was of considerable interest and encouragement to us, inasmuch as this very prestigious protein research group is taking essentially the same approach to rapeseed that we are to coconuts.

Dr. Von Hofsten of the Institute of Biology is making a study by electron microscopy of the cellular structure of rapeseeds. Her most interesting observation was that in the center of the protein bodies is a vacuole which she believes cortains the anti-nutritional factors of rapeseed. She has no direct evidence that these are anti-nutritional factors, but has some presumptive basis for believing that they are.

Three extraction processes have been used to produce rapeseed protein. In the first, rapeseeds were rolled and water extracted. Proteins were separated from some of the other extractables by gel-filtration. The solid residue after protein extraction was dried and solvent extracted to recover the oil. In the second process, the rapeseeds were rolled and dehulled. The oil was solvent extracted, the residue was water extracted, the protein was separated from the water extract by dialysis. In the third process, rapeseeds were rolled, the oil was solvent extracted at room temperature, the residue was water extracted at pH 11.7, and the extracts were purified by gel-filtration at pH 10.

Water extraction in the first process was tried at pH 8 and also at pH 11.7. The protein from pH 8 extraction gave growth rates comparable to

casein. The results of toxicity testing showed some pathological liver cells. Protein extracted at 11.7 remained partially in solution at pH 4, so gel-filtration was required for recovery. Protein from the second process also gave growth rates comparable to casein, but the toxicity has not been measured. In the third process, the water extract at pH 11.7 was stable against bacterial growth for several days. Extraction at pH 11.7 recovers about 90% of the protein. Recovery at pH 8 is about 50%.

We saw a pilot plant under the direction of Dr. Janson, which is capable of processing ten kilograms of rapeseed. It has a Sephadex gel-filtration unit with a column about two feet in diameter. They believe that gel-filtration has commercial possibilities, particularly when one is trying to remove a rather small amount of unwanted components. Their present goal, however, is simply recovery of sufficient quantities of rapeseed proteins so that they can be characterized by molecular weight, isoelectric point, amino acid analysis, biological activity, and solubility.

The Institute is naturally concerned with the materials in rapeseed which are considered biologically undesirable. These are thioglucosides, of which they say there are six in rapeseed. They contend that these materials are not toxic but simply anti-nutritional.

* * *

ALFA-LAVAL AB
Tumba, Sweden

October 17, 1969

Mr. K. Gillis Een, Director of Engineering
Dr. John A. Aspegren, Director, Research and Development Group Staff
Mr. Rune Glimenius, Processing Engineering
Mr. Walter Hoffmann, Manager, Process Development
Mr. Reino Sepp, Manager, Process Laboratories
Mr. Egon Wagemann, Research Engineer
Mr. Sven-Eric Kroon, Sales Engineer

The Alfa-Laval people were very interested in the possibilities of centrifugal processing of oilseed for protein. They are attempting to keep in touch with all developments around the world in this field. Dr. Aspegren appeared to be particularly interested in coconuts. They have developed a centrifugal processing procedure for "petro-proteins". They did not volunteer any of the details of the process, presumably because they developed it in co-operation with some company which is active in the field.

Mr. Wagemann had some photomicrographs of coconut meats showing cells about 50 microns across by 150 microns long. Apparently the cell walls are fibrous and contain the oil and protein within them. They have conducted some experiments on milling of coconut to release the oil and protein. They emphasized the importance of milling upon the efficiency of recovery of oil and protein. They found the most success on a small scale with a cylinder containing glass beads one millimeter in diameter and a stirrer operating at 3000 rpm as an attrition mill.

They said that this is the same type of mill that is being used experimentally with single cell proteins. Only after this mill was used, could they get nearly all of the cells opened and the oil and protein released as shown by microscopic examination. This milling was conducted at a neutral pH. Centrifugation in a tube formed three phases: cream, water, and solids. They said that the separation of the oil and protein phase is difficult, and that it ultimately may be solved by the use of surface active agents (detergents).

A Sephadex fractionation system for cheese-whey has been developed by the Swanson Company of St. Paul, Minnesota. When asked to compare the merits of gel-filtration with membrane filtration, Mr. Aspegren said that he

felt gel-filtration would be applied where fractionation was desired and membrane filtration would be used for concentration.

Alfa-Laval feels that having to separate oil from fiber, as in the TPI process, is undesirable.

* * *

THE PROTEIN FOODS ASSOCIATION OF INDIA October 20, 1969

Mr. A. V. Mody, Vice Chairman, P. F. A.
Unichem Company
Bombay, India

Mr. Mody is presently Vice Chairman of the Protein Foods Association and it is expected that he will be the next Chairman. The Association is a group of about twenty-five Indian companies interested in the promotion of new protein foods. They have made modest financial contributions to establish the Association whose present activities are centered primarily around market surveys.

Mr. Mody is the owner of Unichem, a pharmaceutical company. This company has several hundred detail men contacting physicians and drug stores. Consequently, Mr. Mody is looking for ideas of foods that he can sell through contacts of this sort.

He is presently experimenting with a cookie (an Indian biscuit) which includes pre press solvent extracted peanut flour obtained from the Tata Oil Mills Company. This biscuit is formulated to supply a substantial quantity of well balanced proteins. Like everybody else in India, with very few exceptions, Mr. Mody is more inclined to be interested in the protein efficiency ratio than in any other characteristic of his product. However, he is a practical businessman who has become aware of the importance of consumer acceptance

and has in fact scaled his ideas of the required protein content for the biscuit down from his original thinking of 25% to his present product which is about 18% protein. This was done to make the product more acceptable to the consumers.

Mr. Mody is progressive and receptive to new ideas. However, his products must be limited to those which can best be marketed through his doctor detail men. We suggested that he might consider marketing a coffee whitener or a tea whitener, inasmuch as rather large quantities of boiled milk are used for this purpose in India.

Mr. Mody expressed interest in products which could be produced by continuous cooker extruders such as mixtures of cereals with oilseeds or oilseed products. He is also interested in the possibility of marketing a blend of wheat flour enriched with peanut flour. Customarily, Indians purchase wheat and have it ground into flour or take it home to grind. This is reputed to be due, in part, to the fact that Indians distrust purchased flour assuming that it might possibly be adulterated. Mr. Mody recognizes that packaging a fortified flour will cause manufacturing problems and increase the cost.

* * *

THE TATA OIL MILL COMPANY, LTD.
Sewri
Bombay-33, India

October 21, 1969

Mr. D. K. R. Rao, Manager of the Oil Mill
Dr. B. P. Baliga, Director of Research
Dr. N. L. Murty
Dr. K. S. Holla
Dr. M. Rajasekharan

In India, about 70% of the coconuts produced are used for edible purposes, chiefly for making curries. The fiber of coconuts has a strong

tendency to absorb fat. When dry, it will absorb 60% of its weight as fat. Dr. Baliga suggested that the most feasible process for producing coconut protein was to dry the coconut meats, extract them with solvent and then extract the protein from the residue. For wet centrifugal processing, he suggested milling the coconut meats with added coconut oil instead of water as a possible means of preventing the formation of emulsions. Dr. Rajasekharan had worked on coconut processing at the Central Food Technological Research Institute in Mysore. Dr. Rajasekharan said that one of the problems with the Kraus-Maffei process at Mysore was the large amount of fiber leaving the press along with the emulsion causing the isolated protein to be high in fiber. In addition, the oil loss in the expeller cake was too high when the feed rate to the press was high enough to be economically feasible.

In Bombay, Tata produces a high quality food grade prepress solvent extracted flour some of which is sold, and the majority of which is used in the manufacture of their isolated peanut protein. The quality of peanuts they use for this operation cost them about eight dollars per ton more than ordinary peanuts. The peanuts are cleaned, blanched and hand picked as if they were going to be eaten as nuts. Then they are screw pressed in one V. D. Anderson expeller. The press cake is accumulated until enough is on hand to make a run in the oil mill solvent extractor. This was reported to be a V. D. Anderson vertical emersion type column with a capacity of forty to fifty tons of prepress cake per day. It has a steam jacketed screw conveyer type of desolventizer.

The specially processed prepress solvent cake is ground into flour in the same area where the cleaning and sorting of peanuts and the prepressing are conducted. The flour is bagged.

Processing in the protein isolation plant is a combination of batch and continuous. Extraction and pH adjustment are batch operations and the drying is a continuous operation. All of the equipment is stainless steel with sanitary dairy type of construction including piping and pumps.

Bags of flour are elevated to a second floor level and dumped by hand into floor hoppers over mixing tanks where room temperature water is added. After mixing, the batch of slurry is run into a basket centrifuge where the insoluble materials are separated from the extract. At the present time, the insoluble materials are discarded. The pH of the extract is adjusted to 4.8 to 4.9 with 5 N sulfuric acid and the protein precipitates. The acidified extract is centrifuged in a continuous centrifuge which discharges a stream of water and a stream of protein solids in the form of a slurry. The aqueous phase is discarded. The protein slurry is neutralized with sodium hydroxide solution, spray dried and bagged.

Hydrogen peroxide is added to the extraction water to aid in the control of bacteria and to provide some bleaching effect on the protein isolate. There are also some indications that hydrogen peroxide aids in the elimination of aflatoxin. Dr. Baliga said that their isolate is consistently devoid of aflatoxin.

The two basket centrifuges performing the first centrifugation are German Kraus-Maffei imperforate basket type with automatic sequencing. Each receives a charge of slurry while spinning. The supernatant is discharged by a scoop with an adjustable depth of travel. Then the solids are also discharged by a scoop.

The centrifuges separating the acid precipitated protein are Danish Titan valve operated machines. Valves in the bowl are opened on a variable

time schedule to allow the solids to be discharged from the disc bowl. The water discharged from both centrifuges was milky but the milkiness was said to be caused by entrained air. The nitrogen content of the water was said to be low.

The pH of neutralization before drying often is adjusted to the customer's specifications. The spray drier is a Danish Niro vertical cylinder with a cone bottom. The drying air is heated to about 200°C. by passage through tubes in an oil fired furnace. Material leaving the drying chamber is cooled by chilled air immediately and then screened. This is mixed with material from the cyclone dust collector and is bagged in an air-conditioned cooled room.

The plant was reported to be running continuously six days per week with four-hour shutdowns for complete cleanup every two days. The selling price of peanut flour is 0.7 to 1.0 rupees per kilogram (4.2 to 6.0 U. S. cents per pound) and of isolated protein is 3.5 to 5.0 rupees per kilogram (21 to 30 U. S. cents per pound).

The Tata Oil Mill Company operates another peanut protein isolate plant at Ahmedabad. This plant uses raw peanuts as feed stock. While the basic process was developed at the Central Food Technological Research Institute in Mysore, Dr. Baliga told us that Tata was the only organization which has thus far industralized the process. Tata was producing about 100 kilograms per day of the isolated protein for use in a new chocolate flavored drink containing about 5% total solids which they were attempting to market. Naturally, the protein produced by this process is more soluble than that obtained from the prepress solvent flour.

In this process, an aqueous slurry of raw peanuts is fed to a three phase centrifuge to produce three product streams: oil, protein extract and

a slurry of insolubles. One change that Tata made from the original CFTRI process and which improved their results was the substitution of a different make of three phase centrifuge for the one originally installed. Presently, their recovery of oil is only 80 to 82% of the theoretical amount available. Dr. Baliga believes that the affinity of the fiber for oil is the cause of the low oil yield and he believes that this problem will be worse in wet coconut processing. Tata also has some emulsion problems similar to those which have been encountered by the Tropical Products Institute people. Dr. Baliga says that Tata has been getting better separation in continuous centrifuges than tests in a batch centrifuge had indicated they could expect.

It was our impression that Tata had lost some momentum on peanut protein products during the nine to ten months that Dr.Baliga was in the United States. Evidently, Baliga was largely responsible for much of the earlier movement of the products through his personal contacts in the food industry. According to a telephone conversation with Mr. Charles Puttkammer from the U. S. Embassy in Delhi, a number of companies were quite annoyed with Tata because of their very poor handling of this protein business. We received the distinct impression that the market potential for peanut protein products in India is good but that the marketing capabilities within the Tata organization were considerably less than effective.

* * *

CENTRAL FOOD TECHNOLOGICAL RESEARCH INSTITUTE October 23, 1969
Mysore, India

Dr. H. A. B. Parpia, Director
Dr. B. L. Amla, Assistant Director for Information and Extension
Mr. G. T. Ramanathan, Assistant Director for Engineering and Process Development

Dr. M. R. Chandrasekhara, Director of Protein Technology
Mr. N. Subramanian
Mr. G. Ramanathan

It appears that the CFTRI has not done anything with the processing of fresh coconuts for several years. Dr. Parpia indicated that they have no plans to initiate any projects unless they are requested to. Consequently, their present technology does not extend beyond the reports in the literature of their work with the Kraus-Maffei process.

The CFTRI discontinued work on their modification of the Kraus-Maffei process because they could never achieve more than about 80 to 85% of oil recovery. Again, the big negative appears to have been the absorption of oil into the fiber. The present technology of screw pressing copra to 7 or 8% residual oil in the cake represents a 95% recovery of oil. It is believed that any new process must approach this level in order to be an economic success. India simply cannot afford the loss of coconut oil. It is used primarily for soap and cosmetics. Evidently it is very highly thought of both in India and in many other Asiatic countries, not only for grooming of the hair but also as a body oil.

Their coconut processing pilot plant has been partially dismantled when units of equipment were needed in other research. We did see the Kraus-Maffei disintegrating roll which is essentially a shredder followed by two rows running together at about 400 to 500 rpm with some differential in speed. The K-M dewatering press had a perforated cage with openings of 0.05 to 0.10 millimeters. To prevent blinding, the holes were narrower on the inside than on the outside. A pin mill was reported to be the best device for shredding fresh coconut prior to K-M pressing. They used a K.E.K. pin mill manufactured at Ancoats, Manchester, England.

The use of a colloid mill to mechanically break the emulsion produced in the K-M process met with some success. A description of these experiments has not been published. Solvent extraction of expeller cake from the K-M process resulted in good oil yields but the protein recovery was only about 60%. CFTRI has also done some experimentation on the removal of water and oil from undried coconuts by azeotropic extraction with heptane. However, when asked what they believed would be the process most likely to be successful for the recovery of proteins from fresh coconuts, Mr. Rammanathan said that he felt that the coconut meats would first have to be dried and solvent extracted prior to the isolation of proteins.

CFTRI has tried making protein isolates from copra expeller cake. When they used alkali extraction with acid precipitation,they obtained a poor flavor and color. With acid extraction, the flavor and color were satisfactory but the recovery was only about 60%. They tried enzyme digestion followed by extraction and found that the protein then could not be coagulated. They presumed that it must have been hydrolized. The nutritive value of this enzyme extracted protein was found to be low. The enzyme was obtained from Japan.

CFTRI indicated some interest in a beverage made from coconuts. They have done some experimenting with a so called "skim milk" produced by the centrifugal separation of coconut milk into cream and skim milk fractions. Although there seemed to be some difference of opinion of the actual protein composition of a typical skim milk, the only analysis immediately available from their records showed 2.6% protein, 0.8% oil, 5.4% carbohydrates, 1.4% ash and the remainder water. Obviously for the skim milk idea to be successful, it would be necessary to develop processes for recovering useful marketable products from the cream.

The principal product of interest at present in CFTRI is a peanut protein made from solvent extracted peanut flour. We tasted a development product called "Lac-Tone", so called because it is a 50% mixed cow and buffalo milk "toned" with peanut protein dextrose and water to a fat content of 1.5 to 2%. Normally, "toned milk" is fresh milk mixed with dried skim milk and water to lower the fat content by one-half, or in the case of "double toned milk," by three-quarters. "Lac-Tone" could be considered to be doubled toned.

We also saw both wet and dried precipitated peanut protein with which they were working. In the pilot plant, they were attempting to use recentrifugation of precipitated peanut proteins to increase the total solids content of solutions going to the spray drier from the range of 10 to 15% up to 20 to 30%.

The pilot plant was quite well equipped with good process equipment, most of it stainless steel and sanitary design for food use. It was housed in a large, well lighted building designed for the purpose. Some of the principal items of equipment in addition to those mentioned earlier are as follows:

Westphalia Model SAOG-205 Centrifuge with 700 to 800 liters per hour capacity for separation of three phases using intermittently opening valves for solids discharge from the bowl;

Westphalia Model SKOG-205 Centrifuge for separating three phases using continuously open nozzles of different sizes for solids discharge from the bowl;

DeLaval DVK-4G Three Phase Nozzle Type Centrifuge for separating yeast from fermentation liquor;

Sharples Decanter Centrifuge with solid horizontal bowl for relatively easily conducting two phase solids-liquid separations;

Three Disc Bowl Two Phase Laboratory Size Centrifuges;

A small centrifugal Liquid-Liquid Solvent Extractor of German manufacturer;

A Danish Anhydro Spray Drier having 25 to 30 liters of water per hour drying capacity equipped with an oil fired heat exchanger to heat the air;

A Plate-Type Liquid Pasteurizer;

A small Horizontal Flaking Row;

Two Alcohol Recovery Stills which permit alcohol to be concentrated to 95% and from 95% to near absolute;

A small Blaw-Knox Buflovac Drum Drier having drums approximately 6x12 inches in size;

A larger Drum Drier of their own design and manufacture having drums approximately 12x24 inches in size (they are presently making a still larger Drum Drier);

A British APV Company Plate-Type Evaporator having very low contact time for work on high viscosity products;

A Forced Circulation Evaporator;

A chilled water supply to the evaporator condensors;

A Nash Pump for providing a vacuum of about 25 inches of mercury to the evaporators;

A Continuous Drum-Type Vacuum Filter of stainless steel;

Several Cabinet-Type Driers;

Hammer Mills;

A Mikro Pulverizer with stainless steel cyclone collector;

A pilot size stainless steel V-Type Solids Mixer.

Dr. Parpia said that he had recently visited Oregon State College and the University of California at Davis and had pointed out to them where their Food Technology program was deficient in preparing students for useful careers in developing countries. He said that he spent two days at each institution discussing with them the kind of curriculum he feels would be most useful to people who would be coming into laboratories such as his or others in India.

* * *

HINDUSTAN LEVER
Sewri
Bombay-15, India

October 24, 1969

Dr. S. Varadarajan, Research Director
Dr. K. K. G. Menon, Head of Biological Research
Dr. S. S. Kalbag, Head of Process Development

We met only briefly with Dr. Varadarajan and were impressed that his approach to product research appears to be very highly academic. Dr. Menon is definitely biologically oriented and appears to be primarily concerned with nutritional and anti-nutritional factors. Dr. Kalbag, who rather recently came from CFTRI and is a graduate from Purdue University, appeared to be by far the most practical of the three. At CFTRI, Dr. Kalbag worked on the peanut protein process.

Dr. Kalbag was of the opinion that the high fiber content of coconuts makes the recovery of oil by wet processes impractical. Therefore, he believes that a process for the recovery of coconut protein should start with solvent extracted coconut solids.

Hindustan Lever is interested in developing a coconut milk that is not made from coconuts. They feel that coconuts are too expensive for this

purpose. However, they have encountered the problem that there are no coconut flavors available that they consider acceptable. They feel that the flavors that are available are more like that of copra then of fresh coconut.

Dr. Menon pointed out what may be a rather important fact, that is, coconuts are reported to be sensitive to amoebic infestation. This should be checked out very carefully. If true, it should be taken into consideration in research on development of new food uses for coconuts.

Dr. Menon also believes that the nutritional aspects of oilseed carbohydrates is an area where more attention is needed. Past nutritional work with oilseed proteins has to a great extent ignored the nature and biological properties of the associated carbohydrates. Presumably, he is concerned about the reports of gastrointestinal symptoms induced by unfamiliar carbohydrates.

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COCONUT RESEARCH INSTITUTE OF CEYLON
Bandirippuwa Estate
Lunuwila, Ceylon

October 27, 1969

Dr. W. R. N. Nathanael, Director

The Coconut Research Institute is concerned primarily with production problems and is supported largely by a check off system of coconut producers. In Ceylon, agricultural acreages greater than twenty acres are called "estates" while those under twenty acres are called "small holdings".

The use of nitrogen, potassium and phosphorous as fertilizer improves coconut yields. The Sinhalese government subsidizes fertilizer costs by 50%. The average production of coconuts in Ceylon is 2400 nuts per acre per year. The Coconut Research Institute is producing hybrid trees whose nuts average

about 50% larger than normal. One of the objectives of the hybridization research is to produce trees that do not grow so tall. Not only do trees that are more than fifty years old fall off in production but in addition they presently become so tall that harvesting becomes a problem. One of the services that the Institute performs is to provide seedling trees to farmers.

Coconuts set new flowers every month. It takes twelve to thirteen months for the production of a mature coconut. In Ceylon, it is the practice to harvest every two months. At each harvest, the pickers select the two ripest bunches to remove from the trees. Presumably these will be the coconuts that are twelve and thirteen months old. Dr. Nathanael said that there is no significant difference in the composition of coconuts at twelve and thirteen months. They do not wait and allow the mature coconuts to fall. In falling, the coconut shell might be split and if that does happen the coconut deteriorates rather rapidly.

Dr. Nathanael said that dehusked coconuts may be stored two to three months if kept in a shaded place. However, if they are allowed to remain in direct sunlight, the differential in temperature on the sunny and shaded sides may cause the coconut to crack. For maximum stability in storage, the tuft over the three eyes of the coconut should not be removed. It is at this point where spoilage most easily begins. Normally, coconuts are not stored very long after harvest.

The price of coconuts in Ceylon is about 15 to 20 Sinhalese cents each and the price of king coconuts is 75 cents each. The king coconuts are a separate variety that are used primarily as a source of beverage. Laborers at the Institute were being paid 3 rupees per day and skilled labor, 5 to 7½ rupees per day.

Dr. Nathanael said that about half of the coconuts produced in Ceylon are used for food. The average consumption by Sinhalese is 140 mature coconut kernels per year. This does not include the immature king coconuts which are harvested at six months. Of this tremendous utilization of mature coconuts, most people make homemade coconut milk. This is done simply by grating or scraping the coconut meats and then straining them through some device such as cheesecloth. It is general practice to discard the residue which contains about 35% fat on a dry basis. Presently the Oils and Fats Association are collecting this residue from some sources and using it to extract coconut oil for use in splitting into fatty acids. However, their collections represent only a small fraction of the residue that is available. Because of this large consumption of coconuts and of legumes imported from India, Dr. Nathanael believes that protein malnutrition is not a problem in Ceylon. The coconut milk that is produced in the home is used as a base for curries which are used with rice. The coconut residue constitutes a considerable waste on the scale that it occurs in Ceylon.

Lever Brothers-Ceylon are marketing a product called "Coconut Cream" which is intended to replace the home preparation of coconut milk for curries. This is a concentrated coconut cream, a one pound packet of which is said to be the equivalent to the milk of six coconuts.

Dr. Nathanael was, like many other Sinhalese , a strong proponent of the water from the king coconut. He stated categorically that the water from the king coconut is more valuable nutritionally than that from a mature coconut. He said that it contains 4% glucose and various unidentified growth stimulant and diuretic agents. Later conversations suggest that this opinion is based more on folklore than on science. The king coconut is harvested at six months

simply to provide a beverage. The end is chopped off the coconut using a heavy knife to form a natural cup and the water is then consumed and the remainder of the coconut thrown away. To the Sinhalese, this is a very refreshing drink but it appears to be a very wasteful use of the coconuts.

For making copra, coconuts are husked, shelled, split and spread to air dry for one day on a platform raised above the ground. Twelve to fifteen percent moisture reduction is accomplished in this period of time. Drying should begin within four hours after the nuts are split, otherwise spoilage will begin. Copra should be protected from rain during drying. Some completely sun drying is conducted in the dry areas of Ceylon, however, most copra is produced by a combination of one day of sun drying followed by five days of kiln drying using coconut shells for fuel. About two-thirds of the shells are consumed in this way. The objective of drying is to reduce the moisture content to 6%. Such copra will have satisfactory storage qualities. The temperature reached inside the kiln is about 80°C.

In Ceylon, copra is graded into "edible" and grades 1, 2 and 3. Edible or white copra is produced by so called "patent driers" or by using a smokeless coconut shell charcoal as fuel in the kilns. Dr. Nathanael said that most of the edible grade coconut was exported to India where it received a premium price inasmuch as it produces a good quality oil which is used for food and cosmetic purposes without refining. Later conversations with the people at Lever Brothers suggested that the export to India was not as large a component as had been inferred by Dr. Nathanael. The copra is graded according to color, brittleness and degree of deterioration. Dr. Nathanael tried to show us samples of the edible white copra but none of the samples that were brought in came up to the standards he said were required for shipment to India.

Copra is subject to growth of molds and fungi if not properly dried causing a lowering of the grade. Aflatoxin is found in this copra. Drying at too high a temperature can also cause a lowering of grade. Copra is also subject to insect infestation. The Coconut Research Institute has developed construction plans for kilns and complete instructions for copra manufacture, which if followed carefully, are reported to insure production of good grades of copra.

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INSTITUTE OF SCIENTIFIC AND INDUSTRIAL RESEARCH
31 Torrington Place
Colombo 7, Ceylon

October 28, 1969

Mr. S. F. Laurentius

Mr. Laurentius had worked at the Tropical Products Institute in England for one year ending last August. He worked on several phases of the TPI coconut process. He said that when they used a colloid mill for grinding the coconuts, the maximum extraction of oil that they obtained was 86%. When they set the mill to obtain a maximum oil extraction, the fiber would be ground so finely that it would cause the mill to choke. For example, at 0.005 inches setting on the colloid mill, the feed rate was low and the mill was likely to choke and in addition the screen used to separate the fiber was easily blinded. On the other hand, at a setting of 0.02 inches on the colloid mill, the operation was much smoother but the oil recovery achieved was 86%. They were seeking a 90% oil recovery as a minimum.

Mr. Laurentius described the process developed by ICAITI in Guatemala. This process was very similar to the TPI process except that a rod mill was used for disintegrating the coconut meats. In the ICAITI process, coconuts

and water were passed through a rod mill to produce an emulsion. The emulsion was screened to remove the fiber and then passed through a centrifuge. Their major effort was to produce an unstable emulsion so that the oil could be released and separated in the centrifuge. According to Mr. Laurentius, ICAITI never succeeded in producing such an unstable emulsion and have ultimately abandoned the process.

Laurentius is working on a process for the commercial manufacturing of coconut milk or coconut cream. He uses a two to one water to coconut ratio which produces a slurry which separates into a cream and a serum. The cream represents 70% of the volume and after homogenizing and pasteurizing, can be used for curries. The serum which is about 2% solids represents 30% of the volume and contains primarily carbohydrates, minerals and some small amount of nitrogen. When the serum was spray dried, it could not be reconstituted. He has found that with the use of sodium lauryl sulfate, the oil content of the fibrous residue can be lowered to as little as 3%. He said that when the emulsion is acidified, the oil and protein can be separated by filtration at the temperature of Sinhalese laboratories. However, he was not able to do this at the temperature of an English laboratory. The Ceylon Institute of Scientific and Industrial Research is continuing to work on the wet processing of coconuts.

Mr. Laurentius feels that it is important to find a use for the fibrous residue. It apparently has a tremendous affinity for fat and we suggested the possibility of utilizing this property. Subsequently, the thought has occurred to us that this property could constitute a serious disadvantage if foods containing substantial quanities of coconut fiber were ingested. They probably would be excreted almost quantitatively and might carry with them substantial quantities of dietary fat and fat soluble vitamins.

Mr. Laurentius believes that the best use of coconut protein isolate would be for the fortification of bread. He believes that the school age population should be the first target. He stated that the villagers do buy bread. The Sinhalese government has a monopoly on the import of flour, therefore it could be easy to incorporate coconut protein into the flour if the government would decide to do so. He has tried flour made from coconut expeller cake in bread at 5%, 10% and 15% levels. The 5% addition caused a noticeable change in the quality of the bread and the 10 and 15% additions produced unsatisfactory quality bread. He has not tried flour made by the direct solvent extraction of coconuts.

Mr. Laurentius estimated that 40% of the coconuts produced in Ceylon go to domestic use and 60% for industrial purposes. The latter includes desiccated coconut, copra, coconut oil and exported coconuts. It is his opinion that any new coconut process would have to compete with the desiccated coconut industry for raw material because competition with the copra segment of the industry could cause serious economic dislocations.

Mr. Laurentius mentioned the Asian Industrial Development Council whose members are the Philippines, Ceylon, Thailand and India. This group has a coconut committee which is supposed to coordinate work among these nations on coconut processing

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LEVER BROTHERS-CEYLON, LTD.
P. O. Box 283
Colombo 14, Ceylon

October 28, 1969

Dr. J. A. D. Lanerolle
Mr. Daya Senanayake

The per capita consumption of coconut milk in Ceylon is 2 ounces per day. Meat consumption is limited. Dried fish is largely imported. The residue from copra expeller mills is used now for feeding cattle. Ceylon has a limited supply of animal feed. If more coconut protein were deverted to human consumption, Dr. Lanerolle believes that it would necessary to import animal feed.

Lever Brothers-Ceylon is marketing a new product called "Coconut Creem". According to the label declaration on the carton, "Coconut Creem" is composed of coconut fat, milk proteins, carbohydrates and added vitamins A and D. It is packaged in one pound units in a plastic bag inside a rectangular cardboard carton similar to a butter carton. The product is white, has no odor and looks much like a soft shortening. The selling price is 1.9 Sinhalese rupees per pound.

Dr. Lanerolle stated that the sales appeal of "Coconut Creem" was expected to be convenience. It will replace the home preparation of coconut milk which is a time consuming operation. A one pound package will make about the same amount of curry as six coconuts. To prepare the curries, the "Coconut Creem" is blended with appropriate quantities of water.

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APPLIED SCIENTIFIC RESEARCH CORPORATION OF THAILAND October 30, 1969
Bangkhen, Bangkok
Thailand

Dr. C. Lewis Wrenshall, UNIDO Advisor
Dr. Kasem, Director
Dr. Sman, In Charge of Food Technology

The Applied Scientific Research Corporation of Thailand was set up by an act of the Thai government. Dr. Wrenshall is assigned there as a

representative of the United Nations Industrial Development Organization. Their principal areas of interest are food, building materials, metallurgy, industrial chemicals, medicinal plants and the technology of fiber products from jute and kenafe.

Dr. Wrenshall stated that most of the coconuts produced in Thailand are consumed as food and that the supply just about equals the demand. Thailand does not manufacture copra but does import coconut oil for use in soap. We asked what protein supplement was used for livestock and Dr. Wrenshall said that the water buffalo subsists on grass and hay.

In home use, the coconuts are scraped to make coconut milk for curries and the residue is discarded much as is done in Ceylon. Dr. Wrenshall would like to see the production of coconut milk commercialized inasmuch as this would make it possible to double the yield of milk from the same supply of coconuts. In making milk, he feels that it must be made from pared coconuts with the testa removed. The testa contains materials which darken on processing and storage. They have found no way to sterilize the coconut milk without causing a curd to form. However, while the curd is still warm they break it up by homogenization and a fluid milk is once again obtained. It is packaged in a bottle or in a plastic bag. They can do some post-heating but not too much because the product will curd again. A Thai company is reported to be interested in marketing this product. A patent has been applied for in Australia but not in Thailand because the latter does not enforce patent laws.

Dr. Wrenshall showed us several other products that are being developed by ASRC. One is a coconut honey made from coconut milk which was concentrated by evaporation and mixed with invert sugar. The consistency was

approximately that of honey and the product had a pleasant coconut flavor and aroma. We later saw a product like this on sale in Hawaii. Another product ASRC are working with is a coconut-soy beverage made from coconut milk and soy milk. They are also working with some snack items. One was a fried chip containing 16% protein which was made from a blend of soy isolate and tapioca which was mixed into a stiff dough, sliced and deep fat fried. This product had a very good flavor. Another product that they called "Bean Stalk" contained 18% protein. It was a fried mixture of sesame seed, sesame flour, defatted rice bran flour, wheat flour and mung bean flour.

Dr. Wrenshall said that soybeans are produced in and exported from Thailand. One use of soybeans is in tofu, but for this purpose the Thais generally prefer mung beans which are 25% protein, low in fat and higher in starch. The production of mung beans is double that of soybeans. Some of the mung beans are exported to the United States for bean sprouts. Noodles are made commercially from mung bean starch and the protein is commonly discarded in this process. ASRC is interested in trying to increase the food use of soybeans in Thailand.

ASRC may conduct work for outside organizations. They did a survey for Archer-Daniels-Midland on the possibility of marketing a textured vegetable protein in Thailand. In addition, ASRC is presently interested in the possibility of solvent extraction of rice bran and the solvent milling of rice.

* * *

INSTITUTE OF FOOD RESEARCH AND PRODUCT DEVELOPMENT October 30, 1969
Kasetsart University
P. O. Box 4-170
Bangkok, Thailand

Dr. Amara Bhumiratana, Director of Institute

Dr. Insee Chandrastitya, Governor of the Applied Science Research Corporation
Dr. Mike McGarry

Dr. Amara had a luncheon served for us at the Institute. In it were included several recipes with which his Institute is working. These included:

(a) a mixture of soy protein curds with other ingredients that were spread on bread and then toasted;

(b) a cabbage roll which included soy protein and peanuts among its ingredients;

(c) rice with a curry made from coconuts.

Dr. Amara has been developing a canned concentrated coconut milk. The milk is made by grating coconut on a spiked roll and pressing the gratings in a small homemade screw press. The press was constructed of brass and the cage had round holes about 3/32 inches in diameter. The milk is concentrated in a thin film evaporator and packaged in lacquered cans. It was reported to be stable for at least two years. Only pared coconuts were used with added sodium bisulfite to prevent browning. The concentrated coconut milk contains about 13% moisture and 70% oil. Dr. Amara was not optimistic about the possibilities of commercial success with this product because of the high cost of production and the unavailability of high quality tin plate in Thailand.

Dr. McGarry is a Canadian who was working at the Asian Institute of Technology at Kasetsart University. He was doing research on the growth of algae on sewage. He had had previous experience in this type of research in Australia and in California. He made the comment that in California there is a plant producing algae whose entire production is being purchased by a manufacturer of adhesives. While we have made no effort to investigate this

report for further details, it does represent an example of determining the useful functional properties of a protein and putting these properties to work.

* * *

USAID/MANILA
Philippines

November 3, 1969

Mr. T. C. Niblock, Deputy Director
Mr. Philip W. Ruppert, Manager, Office of
Industrial Development

Mr. Niblock had only recently arrived to take up his new position in Manila. He indicated a considerable interest in the survey we were conducting. Mr. Niblock said that he would like our report to contain our overall observations on the coconut industry, its problems and both the scientific and economic research that is needed.

Mr. Ruppert contributed generously of his time, helped us in setting up useful appointments and provided us with a substantial amount of background information and material. The AID/Philippines goal is a means for getting coconut proteins into the diet of Filipinos while still producing good quality oil in yields adequate to maintain the income of the coconut industry.

Only about 7% of the coconuts produced in the Philippines are consumed as food. One and one-half million tons of copra are produced annually which yields about 500,000 tons of copra cake containing around 20% protein. About 40% of the copra is pressed in the Philippines and the remainder is exported. The long-range trend has been toward more of the copra being pressed in the Philippines. The oil mills are owned privately. New mills that are constructed are of the screw press type because they are less expensive. The LuDo and LuYm Corporation operates the only prepress solvent plant in the Philippines at Cebu City. In this plant, the coconut is shredded and pressed

to a residual oil content of about 18% and the cake is then solvent extracted. This plant produced 44% of the total exports of copra meal in 1965.

Mr. Ruppert stated that the new processes that have been tried in the Philippines for the production of food grade protein products from coconuts have failed for the following reasons:

(a) the size of the operation was too small;

(b) the plants and processes were uneconomic;

(c) there was not enough or no premium for the higher quality oil produced;

(d) there was no demand for coconut milk;

(e) there were too many intermediate products that had no value.

It has been reported that independent investors named Ramos are installing a Carver Greenfield in the Philippines but Mr. Ruppert did not have any of the details. It was rumored that the equipment was already in the Philippines. The basic component of the Carver Greenfield process is a falling film evaporator which operates at low temperature and under vacuum. In the total process, coconut meats are homogenized along with added coconut oil using appropriate grinding to rupture the oil cells.

This puree of oil and solids is passed through a falling film evaporator and then centrifuged to remove part of the oil. The residue from the centrifuge contains 65% oil. This residue is extracted by solvent to produce an oil and a flour,the latter containing all of the fiber originally present in the coconut meats.

The Carver Greenfield falling film evaporator has been very successful in orange juice concentration. The V. D. Anderson Company in Cleveland, Ohio

has installed a Carver Greenfield pilot plant. It is not known whether this pilot plant has as yet processed any coconuts. Mr. Ruppert indicated that the minimum size economic unit was estimated to be 50 tons of dry coconut meats per day.

According to Mr. Ruppert, the major foods consumed by Filipinos are rice, vegetables, dried fish and a fish sauce that is used for flavor. Their consumption of bread and milk is limited. While an imitation milk based on coconut proteins might be an approach to improving the diet of the Filipinos, this would be contingent upon developing an acceptability for the milk. The Filipinos do like sweet drinks. They produce some mungo beans which are used primarily to make noodles.

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NATIONAL SCIENCE DEVELOPMENT BOARD
95 East Rodriguez Street
Quezon, Manila
Philippines

November 3, 1969

Dr. Juan Salcedo, Jr., Chairman

We met briefly with Dr. Salcedo to explain our mission. He was most interested and offered the fullest cooperation of his organization. The NSDB is a government agency consisting of a number of commissions or institutes which include the following:

National Institute of Science and Technology (NIST)

Philippine Atomic Energy Commission

Philippine Investors Commission

Philippine Coconut Research Institute

Philippine Textile Research Institute

Forestry and Forest Products

NATIONAL INSTITUTE OF SCIENCE AND TECHNOLOGY
Herran Street, Manila
Phillippines

November 3, 1969

Dr. Jose R. Velasco, Commissioner
Dr. Flaviano M. Yenko, Deputy Commissioner

The National Institute of Science and Technology is divided into ten or more research centers. We later visited several of these. Attempts have been made to produce concentrated canned coconut milk but the project has been deterred by the expense of the cans and the darkening of the products due to iron in the process equipment. Dr. Velasco said that two deterrents to greater utilization of coconut as food are the indigestibility of the fiber and the laxative effect resulting from eating large quantities of coconut oil. The Subramanian acid or alkali pre-treatment of coconut meats for copra manufacture has not been adopted because the treated copra resulted in no greater economic return to compensate for the added expense. In fact, Dr. Velasco suspects that deteriorated copra may be preferred by many buyers because the oil content is higher. Further, the acid treated copra was found to be corrosive to handling and processing machinery.

Dr. Velasco believed that research is needed to correct the disadvantages of coconut oil, of coconut protein, the oxidation of copra meats and to achieve a separation of fiber from protein in coconut flour.

Peanuts are an important Philippine crop and the nuts are eaten either roasted or boiled. There is a rather high rate of liver cancer in the Philippine which may be caused by the aflatoxin in the peanuts.

Copra, mahogany lumber and hemp are the three major Filipino exports. Copra is first but lumber is moving up rapidly.

FOOD AND NUTRITION RESEARCH CENTER (NIST) November 5, 1969
Herran Street, Manila
Philippines

Dr. Conrado R. Pascual, Director
Mrs. Estelita M. Payuma, Chief, Food Technology Branch
Mrs. Olympia N. Gonzalez
Mr. Alfredo C. Guerrero

The FNRC has conducted nutrition surveys which were reported in the Philippine Journal of Nutrition, Volume 22, April-June, 1969. These surveys showed that the average caloric consumption in the Philippines was 1762 calories per day which Dr. Pascual considers to be about 86% of minimum requirements. The protein consumption was estimated to be 92% of the recommended minimum amount of 1 gram of protein per kilogram of body weight per day. Fat consumption is also low in the Philippines.

The FNRC has set up 207 nutrition councils throughout the Philippines at the local level. The objectives of these councils are:

1. nutrition education;
2. home food production;
3. feeding of preschool children;
4. training.

Through these nutrition councils, Dr. Pascual hopes to try to inform the people of the various areas about the status of nutrition in those areas.

Dr. Pascual was particularly concerned about the fact that 50% of the Filipino children are malnourished. He said that the reasons for malnutrition in the order of importance were:

1. lack of availability of proper foods in the markets;
2. lack of adequate income to purchase the foods;
3. and lack of knowledge about what foods are needed for good health.

Dr. Pascual is interested in the development of low cost protein foods for dietary improvement. For this purpose, he is most anxious to see a breakthrough in the economic production of a coconut protein isolate. He referred to the research of Dr. Emett Bolt who had tested coconut protein isolate and found it to be very nutritious. On the other hand, Dr. Pascual said that nutritional results with coconut flour have not been very satisfactory.

The PNRC have made some coconut protein isolates on a laboratory basis. Their objective has been to produce a bland isolate. For this purpose they have grated fresh coconuts with an equal amount of water and have pressed out the coconut milk. Coconut water may be used as part of the added water. The milk is centrifuged to produce cream, skim milk and a small amount of insoluble solids. The cream contains one-third of the protein and the remainder is in the skim milk. The skim milk is heated to coagulate the protein which is then separated from the whey. They prefer a heat coagulated protein to an acid precipitated because of the acidic flavor of the latter and the fact that the neutralized product has been somewhat darker than desired.

They have made a chocolate flavored beverage from this isolate. The beverage is made in a kitchen blender from a combination of the coagulated protein, some coconut oil, whey from the skimming of the cream and added chocolate flavor. The product has been formulated to have a 3½% protein composition. This chocolate beverage retained an undercurrent of coconut flavor which they believe would be fully acceptable. Dr. Pascual does not consider that this drink has a very promising future because of the present high cost of producing the protein isolate.

If water is not added during the grating of the coconut, the cream will not separate from the skim milk. The FNRC people feel that coconut cream is popular with Filipinos and probably could be a marketable product. They have found that the cream emulsion tends to separate so they have added sodium caseinate as an emulsion stabilizer.

We tasted some very acceptable cookies which contained 20% of coconut flour and 20% of coconut paring flour. Both flours had been produced by the Franklin Baker Company by screw pressing dried parings and desiccated coconut.

The FNRC has developed two weaning foods which look very interesting. One is a therapeutic product and contains 38% protein. It is made from coconut protein isolate, mung bean flour, rice flour with 5% fish protein concentrate added to provide amino acid balance. The other would be a staple weaning food containing 25% protein. It is made from a blend of coconut skim milk, mung bean flour, rice flour and 5% fish protein concentrate. The samples we saw had an attractive appearance and odor. They looked very much like high quality infant foods produced in the United States. These products had been produced on a small drum drier in the Industrial Research Center of the NIST. The products had been approved by a taste panel but had not yet been nutritionally tested. Dr. Pascual said that there were two Filipino companies who have shown some interest in these products.

The original work on the Subramanian acid or alkali dip process for copra was done at the Food and Nutrition Research Center. Alkali was considered to be preferred to acid for both practical and economic reasons. Dr. Pascual believes that some of the larger processors are using the alkali dip process because it makes it possible for them to hold the copra longer at a lower

moisture content so that they can sell under the most favorable market conditions. Copra is priced on the basis of moisture content with the lower moisture product bringing higher prices. The exporters may receive a higher value for copra with a lower free fatty acid but it is possible that this price advantage is not reflected in the price paid to the farmer. The inequities in copra pricing at the various exchange points in the marketing process may be what has prevented a more widespread adoption of the Subramanian procedure.

Although efforts are being made to introduce soybeans into the Philippines, Dr. Pascual does not look upon soybeans as the solution to the nutritional needs of his country. This is because of economic problems and because the soy is not a familiar item in the Philippines.

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INDUSTRIAL RESEARCH CENTER (RIST)
Herran Street, Manila
Philippines

November 6, 1969

Mr. Felipe L. Santillan, Director
Mr. Conrado E. Lotho, Assistant Director
Mr. Pedro C. Catanaoan, Jr.
Mr. Palridel H. Recado
Mr. Guillermina C. Manallac

The IRC people stated that coconut protein denatures at temperatures above 90°C. They believed that the material temperature in the Proctor-Schwartz drier at the Franklin Baker Company in Davao is about 105 to 110°C. This is about the same temperature attained in the fluidized bed drier with which they have been experimenting, but they feel that the latter has the advantage of a shorter retention time. However, they have had difficulty preparing satisfactory products with the fluidized bed drier. The rejects have been caused by wet

feed material sticking to the perforated screen in the bottom of the drier. This material scorches to a brown or black and causes specks in the finished product. They believe that they can solve this problem by replacing the screen with one made of teflon.

Mr. Lotho said that a two person team of a sheller and a parer can process about 1000 coconuts in an eight hour day.

The IRC is now working on a wet coconut process which they call the "RIST Improved Coconut Meats Process". It is similar in many respects to the Tropical Products Institute process. Coconut meats are milled with coconut water and pressed in an expeller to produce coconut milk and a press cake. The milk is centrifuged in a basket centrifuge to separate the solids which came through the press screen. It is then centrifuged to three product streams: a cream, a skimmed milk and a protein solids. The combined skim milk and protein solids are then either drum or spray dried. The cream from the centrifuge is heated to break the emulsion and to precipitate any protein. This is then centrifuged to separate the protein from the coconut oil. The solids from the dewatering press are dried and solvent extracted to produce oil and a high fiber meal. We inquired about the material balance on the process and analyses of the products and were told by Mr. Recado that he would send us this information. It has not yet been received. We were given samples of the drum dried protein. (The two samples differed substantially. One had a light color and a pleasant odor; the other had a scorched color and odor. Our analysis indicated that the lighter sample contained 20% protein which had only been slightly denatured as measured by its pH-solubility profile. The scorched sample contained 30% protein whose solubility was intermediate between that of

an undenatured product and a screw pressed meal. While this would not suggest any reduction in nutritive value, it would be expected that this sample would have its functional properties substantially altered.)

The processing pilot plant of the Industrial Research Center was rather impressively supplied with equipment. Much of it was good equipment made of stainless steel. The best looking was that received from Japan as reparation payments. They have a German colloid mill and a single disc attrition mill of Philippine manufacture. At the present, the IRC staff do not seem to have a preferred method for grinding their coconuts. They have been dewatering the milled coconut meats in a Japanese made screw press. They are presently constructing in their own shop a one-pair high dewatering roll which operates like an old fashioned laundry wringer. They said that preliminary experiments have indicated that this method of dewatering will be quite effective with milled coconut meats. Among other equipment observed were:

Several stainless steel jacketed tanks with agitators

Three disc-bowl liquid-liquid centrifuges

A horizontal spray drier

A milk evaporator with a coil type heater

A small Buflovac vacuum drum drier

A larger atmospheric drum drier

A pressure or vacuum double arm mixer of about 1 cubic foot capacity

Several basket centrifuges of different sizes, the largest having a bowl about 2½ feet in diameter

An oil hydrogenating and deodorizing facility

BIOLOGICAL RESEARCH CENTER (NIST)
Herran Street, Manila
Philippines

November 6, 1969

Mrs. Luz Banes-Arcega, Director
Mr. Macario Palo
Mrs. Dolores Hipolito
Dr. Clare Baltazar

The program of the Biological Research Center is microbiologically oriented. They have worked with coconut water, copra meal, coconut husks and coconut flour. The research they discussed with us was mostly based on coconut water. They have produced a 50% protein concentrate by growing strawberry yeast on coconut water with added nutrient salts. They said that mushroom mycellium will also grow well on coconut water and the product will contain 50% protein. They have also produced vinegar from a mixture of coconut water and sugar. The product that appeared to be most interesting was nata de coco. This is a polysaccharide gel with properties somewhat like gelatin but stiffer and which does not disintegrate when warm. Nata de coco is presently used as a dessert in the Philippines and is being exported to Japan. It is produced by growing acetobacter on a medium containing coconut water, 10% sugar and ammonium phosphate. While this acetobacter will grow on sugar water alone, it was said that coconut water contains some unidentified growth factors which result in better production. (This is one of several references we heard to unidentified growth factors in coconut water. At no time were we able to find any solid scientific confirmation of the existence of such growth factors.) Nata de coco is commonly used in the homes and is presently made in small industries. NIST provides the microorganisms for these industries. Mrs. Banes-Arcega said that the production of nata de coco is fast becoming a food industry. She said that the California Fruit Company (CPC International) is interested in nata de coco and Unilever has asked for samples of the microorganism.

The Biological Research Center has made some study of the solubilization of crude fiber in coconut flour but do not consider this to look too promising at this time. This is due to the slow rate of activity of the enzyme.

Dr. Baltazar showed charts illustrating the work of her group relating the composition of coconuts to their stage of development. The oil and protein content on the basis of yield per nut is highest at thirteen months. These values are nearly on a plateau between 12 and 14 months.

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FRANKLIN BAKER COMPANY
Davao, Mindanao
Philippines

November 4, 1969

Mr. A. C. Maceda, Jr., Plant Manager
Mr. Peregrino H. Quinitio, Manager of Research and Quality Control

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This plant produces desiccated coconut for export to the United States. The husked coconuts are brought to the plant by truck from the farms and are unloaded into a housed storage bin. The current price of coconuts is posted clearly at the entrance of the plant. On the day of our visit, the price was 148 pesos per metric ton. Immature, overmature and cracked nuts are segrated during the unloading and are put back into the truck and deducted from the net weight. Farmers then make copra from these nuts. The percentage of rejects runs between 1 to 7%. The major problem in Mindanao is overmaturity. Many farmers harvest only every three months so that many of the nuts are overmature resulting in a loss of yield in the desiccating operation. In Luzon on the other hand, they are starting to have a problem of receiving undermature nuts as the farmers have learned that these weigh more per nut. In Luzon, the supply of nuts is irregular due to wet and dry seasons. In Mindanao, the rain is spread

out over the year more evenly so that the supply of nuts to the desiccating plant is more constant.

From the storage bin, nuts are loaded by hand onto a conveyor belt to the process section. At this point, any previously overlooked undesirable nuts are culled out. The nuts are shelled and pared by hand. A team of two works together, one shelling and the other paring. The sheller uses a small hand tool that looks like a hatchet on one face and a pry on the other. The parer uses a hand device similar to a potato peeler. For maximum output, the team will switch jobs periodically. The parings appear to be approximately 1/16 inch thick.

The pared nuts go through breakers into a surge bin from where they move onto a large inclined screw elevator where they are washed with water. The washed pieces then go to shredding devices manufactured by Bauer Brothers and which appear to be attrition mills. The shredded coconut drops immediately onto a traveling screen of a Proctor and Schwartz drier.

The maximum temperature of drying air was said to be 240°F. We did not learn the actual temperature of the product going through the drier. (Because the product from the drier shows no indications of a browning reaction, it is a fairly safe presumption that the protein has suffered very little or no denaturation. The drying is by steam heat produced by burning coconut shells. The Davao plant does not use its entire supply of shells for this purpose. However, a plant near Manila has to burn a little fuel along with the shells in order to provide the necessary amount of steam.

From the drier, the shredded coconut is screened into several grades and packed into one hundred pound paper bags. At this point, the dried coconut contains about 3% moisture. We were told that the entire process from the whole coconut to the desiccated coconut in bags requires about one hour.

The coconut water is discarded. Because it is corrosive, the area around the paring and shelling operations was constructed of wood.

The parings are dried in a separate drier and are shipped to another plant where they are screw pressed into oil and paring meal. Paring meal was reported to contain 12% fiber, 12% oil and 18 to 20% protein.

The minimum agricultural wage in the Philippines was said to be four pesos per eight hour day. The workers at the Franklin Baker plant received six pesos per day as a minimum and on a piece work system could earn as much as seven to eight pesos.

The Franklin Baker Company were using extensive precautions to avoid bacterial contamination of their desiccated coconut. They said that the plant was washed down every shift with water containing a bactericide. Only authorized personnel are permitted in the drying area. Before entering, these persons must wash carefully, put on clean smocks and caps and walk across mats soaked in disinfectant.

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USAID/PHILIPPINES
Manila

November 7, 1969

Dr. R. W. Engel

Dr. Engel is the Associate Dean of Research of the College of Agriculture at Virginia Polytechnic Institute, Blacksburg, Virginia who at the time of our visit was a Special Assistant on the War on Hunger to the Philippine Mission. The following are comments made by Dr. Engel.

The Del Monte Company on Mindanao are growing soybeans for about 1000 head of cattle that they have on their plantation. He said that this is done

because the copra cake available in that area is of such low quality. Both Del Monte and Dole have pineapple plantations on Mindanao. Del Monte is not too pleased with the yields they are getting with their soybeans. The Philippine Bureau of Plant Industry is doing breeding work on soybeans.

Dr. Engel is experimenting with the use of coconut paring flour in infant foods. Although this flour contains 11 to 12% fiber, he considers the high fiber no detriment if it is ground finely enough. He is presently feeding seven nursing infants a mixture of coconut paring flour and mungo bean flour.

Dr. Engel said Mr. Quinitio of the Franklin Baker Company had told him that Baker is interested in manufacturing new food products and that they can make mungo flour. The mungo bean has a substantial proportion of lysine which could supplement the rice that is common in the Filipino diet. However, cost is a problem because mungo beans currently sell for 1.5 pesos per kilogram. He said that the Baker Company was producing a coconut flour by screw pressing desiccated coconut which is presently in surplus.

The three companies in the Philippines that have the best marketing organizations are the San Miguel Company (beer and coca cola), the Del Monte Company and the United Drug Company. While these companies may be able to introduce new foods into the Philippines, Dr. Engel believes that none of them reaches the lowest income groups at the present time. United Drug is interested in marketing a weaning food along with a vitamin supplement which they have been selling at a considerable profit for a long time. This vitamin preparation is supposed to combat nutritional deficiencies particularly in pregnant and lactating women.

Dr. Engel said that a large percentage of the coconut palms in the Philippines are on hilly ground unsuited for other agriculture. This could

make accumulation of fresh coconuts for processing somewhat difficult. He believes that it is a situation more suited to copra production.

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KANEGAFUCHI CHEMICAL INDUSTRIES COMPANY, LTD. November 11, 1969
Osaka
Japan

T. Takada, Executive Director
Y. Ishisaka, Planning Division (Interpreter)
E. Harada, Director, Chemical and Fermentation Division
Nobuo Mogi, Director, Research and Development Division

This company is reported to be building a plant to produce 120,000 tons per year of yeast containing 60% protein. The nutrient medium will be normal paraffins. They intend to sell this first as an animal feed. They believe that their cost will make them competitive with other protein supplements which must be imported.

For food applications, they are working with a food company. To avoid any concern about toxicity due to hydrocarbons, their plan is to make protein isolates only for use in foods. They said that the procedure they are using should not denature the protein. They said that it is a difficult isolation and is being done by the food company.

Kanegafuchi is looking forward to an export market among the Pacific islands and along the East Asian coast. However, in their judgement, before they could export any petro-protein as a food they feel that they must have the approval of the U. S. Food and Drug Administration. They say that the U. S. FDA is looked upon as the standard.

Mr. Takada said that they expected to have some isolate by January or February of 1970 and agreed to send us some. They divulged no details of

their processes. However, in considering the potential usefulness of proteins from coconuts, we feel that it is important to be aware of the merits of all potentially competitive products.

Summary, Conclusions and Recommendations

The objective of this survey was to determine the state of the art in the processing of fresh coconuts for food use. Before we embarked on the journey, we read a number of documents received from a variety of sources which discussed new and improved processes for making a variety of coconut protein food products. In several instances, it was reported that plants had been built and were operating based on some of these processes. We could find no evidence that any such plants are in oparation at this time. As far as we could find, all of the processes that have been reported in the literature, with one exception, have been abandoned, even by their initial proponents. The exception is that of the Franklin Baker Company who do have the capability of drying coconut meats and expelling part of the oil to recover a press cake that can be converted into a coconut flour. However, we found no evidence that they have developed a market for this type of coconut flour.

There is still considerable research activity on coconuts, which can be divided into product research and process research. A major area of product research is that of making a more economical and convenient coconut milk. Coconut milk is used extensively in several countries for making curries. Presently, most of the coconut milk is made in the home by a tedious process that is wasteful both of oil and protein. Efforts to commercialize the production of coconut milk either as a whole milk, concentrate or cream should be encouraged. It is estimated that by commercializing the operation, the recovery of nutrients per nut could be approximately doubled. This could be extremely important in countries where proteins and calories are both deficient. There is adequate know-how available to make these products. What is now needed is a marketing

effort. It is recommended that national and international agencies concerned with food and nutrition find means for encouraging the manufacture and sale of coconut milk products in those countries where it is presently popular. For reasons that will be explained later, we do not recommend an effort be made to encourage the use of coconut milk in those countries where it is not now popular.

Another product that may have good potential is coconut honey, which is made from coconut milk and invert sugar. It is a very tasty product that is used like we use honey in the United States. While it might not be considered to be an important nutritive supplement in a tropical country, it conceivably could become an important item for foreign exchange. It is very possible that a good marketing company could develop this into a substantial export business. Here again, the research has been done and what is now needed is market development.

Weaning foods are under consideration in several groups. One of these is experimenting with an expeller coconut flour and if successful could have an available source of supply. The others depend upon coconut milk or coconut protein isolate as a protein supplement, and therefore could not become marketable until these ingredients are available. The same is true of a chocolate coconut protein drink which is based upon a coconut protein isolate. Both a weaning food and an attractive beverage could be important dietary supplements in any of the coconut producing countries. However, one must first devise a means for the economic recovery of the coconut protein.

This, of course, is the objective of the process research which is presently underway. In our judgement, the process most likely to be commercially successful, of those presently under investigation, is that of the Tropical

Products Institute in London. This is a wet process of fresh coconuts which depends upon centrifugal separation into three product streams: oil, protein and water solubles. Because of a troublesome fourth phase which is an emulsion containing both oil and protein, their process is not now economically feasible, as they are recovering only about 85% of the available oil. TPI feels that a breakthrough from this point is more likely to come from basic research on the physical chemistry of the emulsion than it is from traditional process research.

This point of oil recovery bears close scrutiny. It is the real key to any viable process for producing coconut proteins. It is one of the key factors causing the other processes that have been investigated to fail. One must look at the current uses for coconuts in order to see any proposed process in a proper perspective.

In the producing countries, coconuts are used for two purposes: food and copra. Perhaps some of the investigators in the past have been misled by looking too hard at the food uses and ignoring the economics of the copra process. The food uses have been and still are very primitive. In the main, the coconut kernel is scraped out of the shell by hand and squeezed to recover coconut milk. The residue is discarded. The coconut milk probably, on average, represents less than half of the available nutrients in the coconut. It is easy to devise a commercial process that is superior to this and in those countries where coconut milk is used in large quantities, it is our opinion as expressed earlier that a commercially produced coconut milk could become a successful product.

However, the economics of this are not as simple and straightforward as they might seem to be on first glance. The immediate assumption is that

the processor would probably pay about the same price for the coconuts as does the home user. This may or may not be true. One would have to determine where and how the people buy their coconuts and how much they pay for them. It may be that many or most of them have their own coconut tree and never really enter the cash market. It would require some special kind of marketing arrangement to acquire these people as customers. Nonetheless, the basic idea is sound so it should be possible ultimately to overcome whatever marketing problems arise.

However, for any new manufacturing facility the copra industry would be the primary competitor for coconuts. The copra industry is rather deceptive. Superficially it looks rather primitive. Actually, it is quite efficient for what it is trying to do. The objective of the copra industry is to produce coconut oil and copra meal at the least possible cost. One would be hard pressed to try to devise a system that is more economical than that now in use. The coconuts are dried at or near the point of production. The cost of drying is absolutely minimal. They are dried either by the sun or in simple, inexpensive kilns heated by burning coconut shells. Consequently, there is no excess weight shipped from the producing areas to the manufacturing or export centers. The relatively inexpensive expellers which are in common use recover 94 to 95% of the available oil, and there are only two product streams both of which enjoy established markets. It is generally recognized that the production of copra is unsanitary and that copra is often infested with insects and mold. However, this does not appear to have seriously affected either the market or the price for coconut oil and coconut meal.

The other important consideration about copra is that for many of the countries it represents a very important component of their foreign exchange.

Exportable items very properly have high priorities in the governments of developing countries. Any process that would reduce significantly the value of exports would not be very popular. Therefore, if a process for the recovery of coconut protein only recovers 85% of the available coconut oil, this would reduce the amount of exportable coconut oil by 10%.

To look at it from another perspective, at an 85% oil recovery each pound of protein produced would have to bear a burden of about 10¢ for the loss in oil value alone, over and above the cost of the meal and any additional costs in processing. It is because of these considerations that we would not recommend an attempted introduction of traditional coconut milk in those countries where it is not now extensively used. Even commercially produced coconut milk, although having a competitive advantage over home produced milk, would be a substantially less efficient operation than copra processing. Most of the now-abandoned processes started with coconut milk, and ended in a maze of product streams and too-high product costs.

It is our recommendation, therefore, that any further process research for the recovery of proteins from coconuts be guided by the following criteria, in the order named:

1. Economic feasibility: Probably the most important factor is an adequate recovery of the oil. One cannot overemphasize this point. For every pound of protein recovered, there will have been seven pounds of coconut oil in the process. Economically, the oil totally dominates. Any process that ignores this could be pre-doomed to failure. Other factors to be considered under this criterion are proper sizing and location of plants.

2. Profitable disposability of all of the product streams: This has been a major pitfall of most of the processes that have been abandoned

and that are presently under investigation. While they have concentrated their attention upon one product stream, they have created four or five other streams for which markets would have to have been developed. Ideally, a process for coconuts should yield no more than four product streams: oil, protein, fiber and water solubles. A market exists for the oil and it is presumed that markets can be developed for the protein. The fiber and water solubles are unavoidable by-products for which a home would have to be found.

3. Technological feasibility: Based on the accumulated judgement of the many people with whom we talked, there appear to be three processes that should be considered as means for producing food proteins from coconuts. The first of these is to screw press or to prepress solvent extract desiccated coconut. The major advantage of this approach is that plants already exist in which such operations could be carried out. The major disadvantage may be the limited potential food applications of the protein products. The second process would be to prepare coconut meal by traditional solvent extraction procedures, and then look for food applications for coconut flour, coconut protein concentrates and coconut protein isolates made from that meal. The third process would be a modification of the centrifugal system used by the Tropical Products Institute. If successful, this process would have a number of advantages that make its greater technical challenge worth undertaking.

All three of the above processes have the capacity to meet the first two criteria. In our judgement, all three are also potentially feasible from a technological point of view.

4. Market potential of the product streams: Although this should be inherent in the second criterion, it is sufficiently important to

establish as an independent criterion. Each of the protein products developed by any process under investigation should be thoroughly evaluated for its highest and best potential use. It is not sufficient simply to try to do with coconut protein the same things that have been done with soybean protein. Rather, it would be important to determine those uses for which coconut protein products are uniquely useful. This should maximize both their consumption and their economic return to the producers and the processors.

5. Nutritional value: It has been traditional among protein research groups to give nutritional value the top priority. This has led to the expenditure of large sums of research effort on nutritious formulas which have not been able to meet the challenge of the market place. We believe that it is reasonable to start with the premise that coconut protein has been demonstrated to be nutritious, and that processing technologists have become sufficiently sophisticated that they know fairly well what not to do to avoid destroying a protein's inherent nutritional value. We believe that in the processes outlined above, most of the inherent nutritional quality would be retained except for some disproportionation of amino acids that might occur during the isolation procedures (similar to that which occurs during the isolation of soy protein). We do however believe that nutritional value should be a final criterion when food product prototypes have been developed.

General Comments

There are some comments not directly related to the specific objectives of this survey that we think worth recording. We found a number of competent people doing research on coconuts. To a large degree, their research

suffers from several deficiencies:

1. Lack of well thought out priorities;
2. Lack of clear and positive direction;
3. Very little contact with industry;
4. No apparent means to follow through on a product idea.

We became impressed with the fact that the coconut industry is so largely dependent upon a market for coconut oil. Therefore, the internal economy and foreign exchange position of some of the countries we visited depend in very great measure on coconut oil. We suggest therefore that attention should be directed toward the future market potential of coconut oil. In this instance, historical trends could be misleading. Scientific developments of the past decade could exert a major influence on the future markets for coconut oil. It would seem mandatory that people who are concerned about the economies of the coconut producing countries should make a carefully planned survey to determine what the market for coconut oil is going to be ten years or twenty years from now.

Some thought should also be given to an optimum agricultural mix for the coconut producing countries. For example, while we have read reports indicating a substantial amount of intercropping in the Philippines, this certainly was not confirmed by our personal observations. However, our observations were not an investigation and could have been totally nonrepresentative. Evidently, at least one progressive plantation near Davao has decided that coconuts do not represent the best use of their land. We saw young bearing coconut trees being bulldozed out of the way to make room for banana plantations. Dole and Del Monte have both established pineapple plantations in the Philippines. This

will certainly improve the export-import balance. It is possible that there are other crops that might be more useful and profitable than coconuts. It seems that the coconut producing countries should want to have a careful study made of this possibility.