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Final Report

on

Commercial-Industrial Scale Demonstration of New Castor Meal Detoxification and Deallergenation Technology

UNIDO Contract No. 87/146
UNIDO Project No. US/GLO/87/125
Activity Code: J13106
(TEES Project No. 23950)

Submitted to

THE UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Division of Industrial Operations
P. O. Box 300
A-1400 Vienna
Austria

by

Dr. Khee Choon Rhee
Principal Investigator

of

FOOD PROTEIN RESEARCH AND DEVELOPMENT CENTER
Texas Engineering Experiment Station
Texas A&M University system
College Station, Texas 77843-2476

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PREFACE

This contract entitled "Commercial-Industrial Scale Demonstration of New Castor Meal Detoxification and Deallergenation Technology" was officially signed on January 21, 1989 and February 23, 1989 by the United Nations Industrial Development Organization and the Texas Engineering Experiment Station, respectively. All of the objectives outlined in the contract have been met, and this contract therefore is to terminate on December 1, 1989, as agreed to in the contract.

The following individuals at the Food Protein Research and Development Center, Texas Engineering Experiment Station, Texas A&M University System, have participated in the project for its successful completion.

Dr. Khee Choon Rhee, Principal Investigator

Dr. Byong-Ki Kim, Postdoctoral Research Associate

Mr. Leslie R. Watkins, Research Chemist

Mr. Wilson H. Johnson, Jr., Research Associate

Ms. Koom Chang, Graduate Research Assistant

Ms. Susan J. Hall, Technician II

Mr. Patrick L. Burchett, Technician I

Mr. Dennis Hein, Technician I

Ms. Kathy M. Martinez, Secretary

I. INTRODUCTION

A new technology has been developed by the Food Protein Research and Development Center (FPRDC), Texas Engineering Experiment Station (TEES), Texas A&M University System (TAMUS), under the sponsorship of the United Nations Industrial Development Organization (UNIDO), to produce detoxified and deallergenated castor meals for use as ingredients in mixed feeds. A contract was entered into between the UNIDO and the FPRDC to assist in achieving the commercial-industrial scale demonstration of the new technology for detoxification and deallergenation of castor meal.

This project is the third and final phase of the UNIDO-sponsored castor meal program conducted by FPRDC. The first phase of the study, entitled "The Development of a Castormeal Detoxification and Deallergenation Technology. Phase Two: The Definition and Specifications of a Suitable Technology for Application in Industry," was initiated in May 1983 and completed in September 1984. (The Phase One study was conducted at another institution.) This phase of the study was preliminary in nature to determine if castor meal can be detoxified and deallergenated such that the resulting product can be used as an ingredient for mixed animal feeds.

Based on the positive results obtained from the first phase studies, the second phase of the study, entitled "The Development of a Castormeal Detoxification and Deallergenation Technology. Phase Three: Operations," was initiated in June 1985 and completed in August 1986. The objectives of this phase were to determine if the new detoxification and deallergenation technology, which was developed in the first phase of the study (Phase Two), can be scaled up to commercial operations. to identify and select process equipment to achieve the goal, to determine the nutritional adequacy and toxicological safety of the

products and to make recommendations for construction of a demonstration pilot plant. It was determined that the new technology was scalable for commercial production of detoxified and deallergenated castor meals, the newly produced products are safe and nutritionally adequate for use in mixed feeds, and the castor processing industry will benefit from the new technology by adding value to the meal which has largely been discarded or used as a fertilizer or landfill.

As the result of these studies, the third and final phase of the project, entitled "Commercial-Industrial Scale Demonstration of New Castor Meal Detoxification and Deallergenation Technology," was initiated in February 1988. The role of the FPRDC was to assist UNIDO in its effort to transfer the new technology for industrial use. UNIDO selected the castor processing plant of Thai Castor Oil Industries Company, Ltd., Bangkok, Thailand, as the site for the new demonstration/production facilities, and the Anderson International Corporation, Cleveland, Ohio, as the equipment supplier/contractor, to receive the UNIDO funding for the new three metric tons per hour processing facilities. Subsequently, an existing building was remodeled, process equipment installed, start up procedures completed, and the new facility is now fully operational for demonstration and production of detoxified and deallergenated castor meals.

Interested parties from Federal Republic of Germany, Brazil, Israel, People's Republic of China, Republic of Korea as well as Thailand have visited the facility in Bangkok, and plans are currently being drawn up for additional facilities in Germany and Brazil.

II. ACTIVITIES PERFORMED

II. 1. Selection and Recommendation of the Process Equipment

As reported in the Phase Three Final Report, most of the development work was conducted using various types of Wenger extruders (mostly with model X-20, and limited trials with X-25 and X-200 models). A limited number of trial runs were also made with other extruders, such as Anderson 4-1/2" extruder and Triple F extruder. The results of these test runs indicated that both Wenger and Anderson extruders performed satisfactorily. However, it became clear that the equipment fund available to UNIDO was not quite sufficient to include a Wenger extruder in its equipment list, and the principal investigator was asked to recommend alternative sources of less expensive extruders.

Based on the available data, a decision was made jointly by UNIDO and the principal investigator to thoroughly reevaluate the lower cost Anderson 4-1/2" Extruder for its effectiveness in detoxifying and deallergenating the solvent extracted castor meal from West Germany. The conditions used for the detailed reevaluation were identical to those used for evaluating the performance of Wenger X-20, X-25 and X-200 extruders, as detailed in the Phase Three Final Report. The principal investigator was informed in advance by the Anderson International Corporation that, as is the case for most of the Wenger extruders, the process data from a smaller Anderson extruder (i.e., 4-1/2" model) can be scaled up linearly to a larger model (i.e., the 8" model which was finally chosen for the demonstration facility). The entire testing was conducted under direct supervision of the principal investigator with full cooperation of Mr. Maurice Williams of the Anderson International Corporation. Upon completion of all testings, the results were compared with those obtained from various Wenger extruder testings as well as the earlier Anderson runs, and

the findings are summarized below.

1. The Anderson extruder is as effective as the Wenger extruder for purposes of detoxification and deallergenation of solvent extracted castor meals.
2. The Anderson extruder operates very easily, raising the operating temperature rapidly to the desired level and maintaining it there constantly throughout the run without any unusual effort by the operator.
3. The Anderson extruder is able to handle the raw materials equally well whether they are fed to the extruder preconditioned to a desired moisture level or dry along with direct injection of water and/or live steam.
4. The Anderson extruder is easy to maintain and restore to full operation when the run is interrupted due to various external factors such as power failures, overloads, uneven feedings, improper pre-conditioning of feed materials, etc.

On the basis of these additional findings, which confirmed the earlier findings, the principal investigator recommended UNIDO to consider the considerably less expensive Anderson extruder as an alternative to the more expensive Wenger extruder to satisfy its equipment fund limitations.

II. 2. Efficacy Tests for Construction-Grade Calcium Hydroxide (Quicklime)

Chemical- or technical-grade calcium hydroxide is one of the chemicals found effective in destroying toxins and allergens in defatted castor meals. However, the Thai Castor Oil Industries Company found that chemical- or technical-grade calcium hydroxide was rather difficult to obtain and expensive in Thailand, and therefore asked the principal investigator to test if a construction-grade calcium hydroxide or "Quicklime" can be used in its place to effectively destroy toxins and allergens in the defatted castor meal.

The Quicklime levels tested were identical to those for chemical- or technical-grade

calcium hydroxide used in earlier testings. All test runs were made using the Anderson 4-1/2" model extruder. The results clearly indicated that Quicklime is as effective as the chemical- or technical-grade calcium hydroxide in detoxification and deallergenation reactions. The locally purchased lime contained 94% active ingredient, calcium oxide (CaO). However, since the quality and composition of the construction-grade calcium hydroxide that can be obtained in Thailand are not known, the principal investigator recommended the Thai Castor Oil Industries Company to carry out a series of animal feeding tests to determine the safety and nutritional adequacy of the new construction-grade calcium hydroxide treated castor meals.

II. 3. Separation of Protein-Rich and Fiber-Rich Castor Meal Fractions

One of the problems the detoxified/deallergenated defatted castor meal had to face when used the treated castor meals as ingredients for mixed feeds for poultry and swine was the exceptionally high fiber content, usually in the range of 30-35%. This high fiber content effectively limited the amount of the treated castor meal that could be used in various feed formulas. In an attempt to resolve the problem, a series of screening tests was conducted for the Thai Castor Oil Industries Company to see if a high-protein fraction, which will be more desirable for mixed feed formulation, can be produced. All testings were done on raw materials as they were received without any attempt to further reduce the particle size through additional grinding.

The test results show that the defatted castor meal can easily be separated into a high-protein and a high-fiber fractions by simple screening. The use of a 10-mesh screen produced a high-protein fraction consisting of 41% protein and 27% crude fiber and a high-fiber fraction consisting of 26% protein and 37% crude fiber. When a 16-mesh screen was used, a protein-rich fraction with 45% protein and 21% crude fiber and a fiber-rich fraction

with 20% protein and 35% crude fiber were obtained.

The follow-up extrusion testings, using the Anderson 4-1/2" extruder, confirmed that these two protein-rich and fiber-rich fractions can be detoxified and deallergenated as easily as the original unseparated raw material.

II. 4. Enrichment of Protein-Rich and Fiber-Rich Fractions

In order to further increase the value of the protein-rich fraction as a feed ingredient and the fiber-rich fraction as a fertilizer, a fermentation yeast by-product and an Ajinomoto by-product were respectively added to these fractions and the mixtures were treated with Quicklime for detoxification and deallergenation. The amounts of these by-products that could be added were very small because of the limitations imposed upon by the final moisture content of the meal, around 20-24%. Tests showed that adding these by-products does not alter the chemistry of detoxification and deallergenation and the Anderson extruder also performed satisfactorily.

II. 5. Training of a Quality Control Laboratory Technician

As agreed in the contract, an intensive four-week training was conducted at FPRDC for a quality control laboratory technician during March 21 - April 15, 1988. Topics involved for the hands-on training were: extraction, isolation, purification and identification of CB-1A and ricin; preparation of CB-1A antibody; hemagglutination method for ricin; immunodiffusion method for CB-1A; and Rocket immunoelectrophoresis. The entire training was conducted by Dr. B. K. Kim of the FPRDC who has been involved in the project from its initiation to conclusion.

II. 6. Production of Large Quantities of Samples for Animal Feeding Tests

Approximately three metric tons of detoxified and deallergenated products were produced and shipped to Thai Castor Oil Industries Company in Bangkok and Lohmann

Tierernaehung GMBH in West Germany for use in their animal feeding tests. The bulk of the products was produced from the original unscreened defatted castor meal from Germany, but several hundred pounds each of the protein-rich and fiber-rich fractions, with or without the Ajinomoto or fermentation yeast by-products, were also sent to both parties.

II. 7. Preparation of Additional CB-1A and CB-1A Antibody

At the request of the Thai Castor Oil Industries Company, about 25 ml of additional antibody solution was prepared and hand-delivered by the principal investigator during one of the visits to the company. This additional antibody will be used as a control in comparing the antibody activities of locally prepared antibody preparations.

The FPRDC also donated about 20 grams of the CB-1A allergen preparations to the Thai Castor Oil Company for use in preparing its own antibody preparations under a contract with a local medical school.

II. 8. Visits to Thai Castor Oil Industries Company

Four 5-7 day visits were made to Thai Castor Oil Industries Company in Bangkok during May 21-26 and October 8-13, 1988, and May 27-June 2 and July 25-30, 1989 to: 1) inspect the progress of site preparation for construction of the demonstration plant; 2) review blue prints for the plant; 3) assist in setting up quality control laboratory facilities by identifying and selecting appropriate analytical laboratory equipment and chemicals; 4) learn the plans for the scheduled animal feeding tests; and 5) to assist the training of laboratory quality control technicians in charge of the project.

The plans for site preparation and identification and selection procedures for process equipment were reviewed during the first visit. I was told that the building can be made ready with a short notice to receive the new process equipment. It seemed that some remodeling will be needed by removing some of the existing walls and erecting new ones

as needed. Many of the necessary laboratory equipment, apparatus and chemicals have already been ordered. In addition, I have purchased and delivered personally some of the immunodiffusion test apparatus for them. As far as the laboratory space is concerned, Thai Castor Oil Industries Company is planning to build a new laboratory within the new processing plant in the near future. It seemed that no definite final plan was drawn up for the animal feeding test.

The second visit consisted of detailed review of the quality control procedures with the new laboratory technicians and inspection tours on the progress of the demonstration pilot plant construction. During the third visit, I was informed that the company has already received most of the equipment shipped from overseas, equipment installations and utility connections were expected to complete by July 10-15, 1989, and the start-up of the plant can begin sometime in the week of July 24th. I also was informed that two engineers from the Anderson International will be departing for Bangkok on July 17 to oversee the final stages of equipment installations and utility connections and to make a series of dry runs. Although July is the busiest period of the year at the Food Protein Research and Development Center, the principal investigator was able to travel to Bangkok again in July to witness and participate in the week-long start-up activities along with three process engineers representing The Anderson International Corporation and one of its subcontractors.

II. 9. Assistance to Quality Control Technicians

During the visits to the Thai Castor Oil Industries Company, the principal investigator made sure to spend a significant portion of his time to review various aspects of the immunodiffusion quality control procedures with the laboratory technicians in charge of the program. Continuous assistance has also been provided throughout the life of this contract

by telephone and facsimile communications.

It is the opinion of the principal investigator that the technicians at the Thai Castor Oil Industries Company are now well-trained in all aspects of the immunodiffusion quality control procedures, and they are capable of making accurate analyses of raw materials and deallergenated products.

II. 10. Dissemination of Information

Various aspects of castor meal detoxification and deallergenation procedures have been reported by the principal investigator through national and international scientific meetings.

1. Deallergenation of Castor Meal: 1988 Update. American Oil Chemists' Society Annual Meeting, Phoenix, AZ, May 8-12, 1988.
2. New roles of Extruders in the Food Processing Industry, World Congress on Vegetable Protein Utilization in Human Foods and Animal Feedstuffs, Singapore, October 8-16, 1988.
3. Detoxification and Deallergenation of Feed Meals. American Oil Chemists' Society Annual Meeting, Cincinnati, OH, May 3-7, 1989.

Additionally, numerous inquiries regarding the detoxification and deallergenation procedures have been answered, mostly by telephone and some in person. The two noteworthy among them were:

1. Mr. Zalman Leibovitz, President, H.L.S. Ltd. Industrial Engineering Company, Israel. (The principal investigator accompanied him to the Thai Castor Oil Company for a tour of the facilities during the last visit.)
2. Mr. Tian Ren Lin, Project Director, Beijing Grain Science Research Institute, Xuan Wu District, Beijing, China. (Visited the principal investigator for a detailed discussion of the castor meal deallergenation procedures.)

Also, the principal investigator assisted The International Castor Oil Association (656 Linwood Avenue, Ridgewood, NJ 07450 USA) in its preparation of Technical Bulletin #1-1989 titled "The Processing of Castor Meal for Detoxification and Deallergenation." This 75-page bulletin reports the UNIDO-sponsored project in detail, along with other prior works in the field, and credits the UNIDO project as the first real breakthrough in castor industry.

II. 11. Assistance to Andefson International Corporation

The principal investigator and the Food Protein Research and Development Center have been in constant communication with engineers at Anderson International Corporation to assist them in resolving any technical problems associated with the project. A particular problem which needed to be resolved was the slurry mixing and delivery mechanism and systems to make a continuous and even injection of calcium hydroxide solutions as well as the construction lime suspensions.

II. 12. Additional Research Activities

At the request of the Thai Castor Oil Industries Company, the principal investigator initiated a series of further studies to determine the lowest detection level of the antigen (CB-1A) by the immunodiffusion method. The results show that as low as 7.5×10^{-9} g (or 7.5 ng) CB-1A can be detected by this method.

II. 13. Progress Reports

The First Interim Report, covering the period from the beginning of the project to May 31, 1988, was submitted to UNIDO on May 31, 1988. The principal investigator paid a visit to Dr. H. Koenig at UNIDO headquarters in Vienna on July 18-22, 1988 to make a mid-term oral progress report (in place of the Second Interim Report) on the project, and to discuss matters involving future activities as the plant construction progresses.

The third Interim Report, covering the period between June 1, 1988 and June 30, 1989, was submitted on June 30, 1989. A second visit to UNIDO headquarters was made on September 27-30, 1989 to make a final overall review of the project. It was mutually agreed during this meeting between Dr. Koenig and the principal investigator that all aspects, except a few minor adjustments to equipment, of the contract have been satisfied, the program has been a successful one, and therefore the project should be terminated on December 1, 1989, as agreed to in the contract, with the submission of the Final Report for the final phase of the project.

III. CONCLUSIONS

Based on the combined results obtained from all phases of the castor meal detoxification and deallergenation studies conducted by the Food Protein Research and Development, the following conclusions are made.

1. A fully-operational, three metric tons per hour commercial-industrial scale demonstration facility has been constructed at the Thai Castor Oil Industries Company, Ltd., Bangkok, Thailand to produce detoxified and deallergenated castor meals.
2. A variety of extruders, including the Anderson and Wenger models and perhaps others, can be used to destroy toxins and allergens present in the castor meal with same efficiency.
3. The construction-grade calcium hydroxide (or quicklime) was as effective as the chemical- or technical-grade calcium hydroxide in destroying toxins and allergens in the castor meal.
4. The Anderson extruders are less expensive than the Wenger extruders on a same throughput basis, and easier to operated and maintain.
5. The newly produced castor meals are deemed too high in fiber content, and only limited amount can be used in poultry rations unless some of the fiber are removed.
6. By using a simple sieving technique, castor meals can be separated into a protein-rich and a fiber-rich fractions. The high-protein low-fiber fraction, after detoxification and deallergenation, can become an ideal ingredient for poultry ration while the fiber-rich fraction can be used as fertilizer after treatment.
7. The laboratory technicians at the Thai Castor Oil Industries Company are well-

trained and confident in all aspects of quality control procedures involving toxins and allergens in castor seeds and meals.

Finally, the principal investigator of this successful UNIDO-sponsored castor meal program is willing to assist UNIDO in any capacity in its future efforts to make this new technology available to any interested parties.