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AGRICULTURAL RESEARCH UMBRELLA

SUB-PROJECT 5

CONVERSION OF BIODEGRADABLE ANIMAL WASTES FOR LIVESTOCK FEED

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EXECUTIVE SUMMARY

The outline of the Subproject was completed in August 1985, and was approved by USAID January 21, 1987. The purpose of the subproject was to strengthen the capability of Indian Scientists to conduct research on processing of biodegradable animal wastes to livestock feed. The main objectives were to increase the quantity and quality of feeds to meet the nutrient requirements of livestock in India. The specific objectives of the Subproject were:

1) To screen micro-organisms that have potential to convert animal wastes to animal feed.

2) To evaluate the nutritional value of the fermented feeds for farm animals and to determine means and economics of including these new feeds into practical livestock rations.

3) To transfer the viable technology of processing feeds from farm/animal wastes to villages and industry.

At the first workshop it was decided to minimize the effort on screening microorganisms (Objective 1), since production of protein by microorganisms had been shown not to be economically feasible.

Five centres were to participate in the Subproject, under the coordination of the ICAR Coordinating Unit. The centres and the primary activity of each were:

a) National Dairy Research Institute (NDRI), Karnal. Toxicological studies of feeds obtained from biodegradation of animal wastes. In 1989 this activity was moved to Haryana Agricultural University (HAU), Hisar.

b) Haryana Agricultural University, Hisar. Biodegradation of wastes from large animals into animal feed.

c) Kerala Agricultural University, Trichur. Biodegradation of wastes from aquatic animal industries into animal feeds.

d) Bombay Veterinary College. Biodegradation of slaughter house by-products.

e) Punjab Agricultural University, Ludhiana. Biodegradation of wastes from poultry into animals feeds.

Detailed objectives were developed for each unit.

The U.S. inputs were to include technical assistance, training of Indian scientists, and acquisition of critical items of equipment. The ICAR inputs were to provide salaries and allowances for staff to work on the Subproject, and funds for an annual workshop, equipment and supplies, and in-country travel.

The technical assistance, equipment acquisition and training have been provided by USAID. Most of the equipment has been

received and only three persons remain to go for training. The ICAR has conducted annual workshops, and has provided funds for some equipment, in-country travel and contingencies. A large amount of staff time has been provided.

Although the Subproject will not be completed until 1992, based on results obtained thus far, outputs have been substantial, especially considering the delays in equipment acquisition and training. Some progress has been made at all centres. In addition to the training, equipment acquisition, and technical assistance provided, important research has been completed. The Subproject has resulted in new procedures and technology, which will be useful in future work by Indian scientists,

The role of the U.S. has been very important for the timely development of technology to convert wastes into valuable feed resources. The results of some of the research will be useful to producers of animal products other countries, also. As a result of the training program, contacts have been established between U.S. and Indian scientists working in the utilization of animal wastes.

It is anticipated that mutual interest between U.W. and Indian scientists will increase in the future. This should lead to follow-on cooperation. It is recommended that the following areas be addressed: 1) Processing, nutrition and feeding; 2)

Pathogenic microbiology; 3) Microbiological degradation and conversion of wastes; and 4) Technology transfer. Perhaps, the future effort should include the broad aspect of utilization of biodegradable animal wastes for sustainable agriculture. Such a project would be interdisciplinary, and would add agronomists and agricultural economists to the effort.

I. Subproject Description

The outline for the Subproject was completed in August, 1985, and was approved by US-AID January 21, 1987. The object was to develop technology to convert waste materials of animal origin into economical feeds that would provide improved rations to animals. Five Indian institutions active in research and development on animal feed were to participate in the research, with coordination by Indian Council on Agricultural Research (ICAR). Specific areas were assigned to each Indian institution.

A. Purpose

1. Statement of Purpose

The purpose of the subproject was to strengthen the capability of scientists in the Indian agricultural systems to do research on conversion of biodegradable animal wastes for animal feed.

There are many competent scientists in India who are qualified to work on these wastes. However, they did not have the training and experience to work in the various aspects of the subproject. Thus, training these scientists was essential. Furthermore, critical items of equipment were needed to work in conversion of animal wastes to animal food.

(a) The main objective of the subproject was to increase the quantity and quality of feeds from non-conventional materials to meet the nutrient requirements of livestock in India. The plan was to develop simple microbial techniques, processes and

equipment to process the biodegradable animal wastes. Towards this end plans were made to:

1) Screen microorganisms that have potential to convert animal waste to animal feed.

2) Evaluate the nutritional value of the fermented feeds for farm animals and to determine means and economics of introducing these new feeds into practical livestock rations.

3) Transfer the viable technology of processing feeds from farm/animal wastes to villages and industry.

At the first Workshop held in New Delhi February 20, 1987 the objectives and general plan of the subproject were discussed. This discussion led to the decision to minimize the effort on one of the research areas, namely, production of protein by microorganisms using animal wastes (Objective 1). It was pointed out that in previous work, mainly in the U.S.A, these processes had been found to be technically, but not, economically feasible. It was pointed out also that when waste products are fed to ruminants, microbial digestion and protein synthesis occur in the rumen, and volatile fatty acids are produced. Thus, microbial protein synthesis would be included in the natural processes that occur in the rumen. The role of the microbiologists in the subproject was defined more broadly to include involvement in microbial degradation and protein synthesis, preservation of animal wastes by ensiling or other means, and screening of waste products and fermentation products for pathogenic microorganisms.

Five centers in India involved in animal nutrition research were selected to participate in the subproject under the umbrella of an ICAR coordinating unit, which was established for this purpose. Each of the five centers assumed primary responsibility for a specific phase of the research as follows:

a) Toxicological studies of animal feeds obtained from biodegradation of wastes. National Dairy Research Institute (NDRI), Karnal. Note : In 1989 this activity was moved to Haryana Agricultural University (HAU), Hisar.

b) Biodegradation of wastes from large animals into animal feeds. Haryana Agricultural University, Hisar.

c) Biodegradation of wastes from aquatic animal industries into animal feeds. Kerala Agricultural University (KAU), Trichur.

d) Biodegradation of poultry wastes into animal feeds. Punjab Agricultural University (PAU), Ludhiana.

e) Biodegradation of slaughter house wastes into animal feeds. Bombay Veterinary College, Bombay.

2. Linkage to Higher Goal

The higher goal of this initiative is to provide more animal products for the diet of the Indian people. Resources for increasing the volume of animal products produced in India are quite limited. Grain and by-product concentrates are used as animal feed in very limited quantities. Most of the cultivated land is used for producing grain and legumes for human food. Only limited amounts of high quality forages are available for feeding ruminants. Large quantities of crop residues are

utilized as animal feed. Use of animal wastes which are generated in large quantities, would enhance the feed supply, thereby increasing the quantity of animal products for the people of India. Some of these wastes are used for other purposes such as fuel (cattle dung), methene generation and soil application. However, it has been shown that the wastes have higher economic value as feedstuffs for animals than for the alternate uses.

B. Specific Objectives

1. Problems/Constraints

Considerable research had been conducted in other countries but limited work had been done in India on the use of excretory wastes as feedstuffs. However, much of the research which had been done in other countries was not applicable to India, mainly due to differences in animal management. For the other wastes, the research data available were very limited. Thus, research on the biodegradable animal wastes was needed in India.

2. Descriptive Statement of Objectives

The plan was for a coordinated effort involving the five centers with clearly defined objectives and work plan.

Toxicological Studies. The toxicological laboratory at HAU is to provide special chemical and toxicological analyses that could not be done at other centers. This center was to serve as the central toxicological laboratory to support the subproject. The objectives of the work at the center were to provide:

1) In-country training for designated Indian scientists.

2) Chemical analyses for the other four centers.

3) A toxicological laboratory for testing for any toxic compounds and antimetabolites that may be found in fermented feeds.

Research on Conversion of Slaughterhouse Wastes. It was decoded that the research would be at Bombay Veterinary College (BVC), since it is close to a large livestock industry, and is the site of the largest slaughterhouse in South or Southeast Asia. The plan was for BVC to focus efforts on rumen and intestinal contents and blood. The objectives of the work were to:

1) Provide facilities for analysis and characterization of slaughterhouse wastes and describe toxic factors, if present.

2) Utilize digestive tract digesta by drying, centrifugation, and production of single cell protein (SCP) by fermentation and ensiling.

3) Utilize blood by drying for non-ruminant feed or for microbial growth.

4) Screen digestive tract digesta for microbes and develop technology to produce SCP.

5) Evaluate the nutritional value of slaughterhouse wastes and/or products of processing the wastes, and determine the technical and economic feasibility of including the new feeds into practical livestock rations.

6) Transfer useful technology to farmers and agencies which serve farmers.

Research on Procession of Large Animal Excreta for Animal Feed. This research area was assigned to Haryana Agricultural University. Although Scientists had conducted preliminary research on the use of chicken litter in ruminant rations, but the plan was for HAU to concentrate research on excreta of large animals (cattle, buffalo, goats, sheep and pigs). The objectives of the work at this center were to:

1) Provide facilities for complete analysis of large animal excreta for nutrients and toxic factors.

2) Increase nutritional value of large animal excreta by microbiological, chemical and physical treatment.

3) Screen for microorganisms which have the potential to convert animal excreta to protein or other nutrient.

4) Develop technology to convert large animal excreta and biogas sludge into livestock feed.

5) Evaluate the nutritional value of processed large animal excreta (or product) and assess the technical and economic feasibility of including these into practical livestock feeds.

6) Transfer technology of the research to farmers.

Use of Aquatic Wastes as Animal Feed. The decision was for this research to be done at Kerala Agricultural University. This center was to concentrate efforts on converting fish wastes, including trash fish, and other aquatic organisms to livestock feed. The objectives of the work at KAU were to:

1) Provide facilities for analyses and characterization of aquatic organism wastes.

2) Maintain or enhance the nutritive value of aquatic organisms wastes.

3) Screen microorganisms capable of converting certain aquatic wastes to single cell protein and livestock feeds.

4) Determine nutritional value of aquatic wastes and by-products, and assess technical and economic feasibility of including these in practical livestock rations.

5) Transfer technology to farmers.

Processing of Poultry Wastes for Animal Feed. This research was to be conducted at Punjab Agricultural University. The poultry industry has been developing very rapidly in the Punjab. The objectives of the work were to:

1) Provide facilities for analysis of poultry wastes.

2) Determine and enhance the nutritional value of poultry wastes for livestock feed.

3) Screen microorganisms capable of converting poultry wastes to single cell protein as feeds for animals.

4) Develop fermentation techniques for production of animal feeds from poultry wastes.

5) Determine the nutritional value of poultry wastes or bioconverted products, and assess the technical and economic feasibility of including these in practical livestock rations.

6) Transfer technology to farmers.

Although measurement of toxic factors was mentioned for other centres in the subproject document, the intent was for this work to be done at the Toxicological Laboratory.

C. Input/Output Matrices

Inputs were to be shared between USAID and the Government of India (G.O.I). The inputs from USAID were to consist of technical assistance, training of Indian scientists and equipment acquisitions. The inputs from G.O.I were to include staff, and funds for travel, workshops, equipment and contingencies.

1. Specification of Inputs

a. U.S. Inputs

Technical Assistance

The plan outlined in the original document, prepared in August, 1985 and approved January 21, 1987 was to utilize two consultants, each for 4 weeks, during each of the 5 years of the subproject. It had been found that a Lead Consultant was very useful to expedite the activities of subprojects. Therefore, shortly after the activation of the subproject the plan was altered to appoint a Lead Consultant for work in the U.S.A, mainly related to training and equipment acquisition; for the Lead Consultant to participate in the Subproject Workshop and visit the participating centers annually; and for other consultants to be invited to India as needed to participate in the Workshop and to give technical assistance on specific aspects. The suggested schedule was included in the Consultancy

Report of J. P. Fontenot of June 28, 1989 (Annex A) and was incorporated in Life of Project report in 1989. In the original document 40 man weeks of technical assistance (costing $180,000) were included.

Training

Plans included training for a total of 39 Indian scientists and administrators for 620 man weeks at a cost of $590,000. Included were 18 ICAR administrators for 76 weeks ($108,000) and 21 scientists from the five centers for 544 weeks ($482,000). The training schedule for ICAR Coordinating Unit included study tours for six persons for the first year and one person for each of the succeeding four years. Each study tour was scheduled for 6 weeks (total of 60 weeks).

The programs for the five centres were as follows:

Toxicology Laboratory. Three scientists were to be trained in Toxicology.

Bombay Veterinary College. The plan was for four scientists to undergo training, each for 26 weeks in the following areas: Isolation of Rumen Bacteria for Pure Cultures, Single Cell Protein Production by Algae and Bacteria, Experimental Methods in Feed Evaluation and Least Cost Ration Formulation, and Computerization of Feed Composition Data and Animal Nutrition Research.

Haryana Agricultural University. One scientist was to be trained in each of the following areas: Microbiological Fermentation of Large Animal Excreta, Pure Culture Isolation from

Large Animal Excreta, Feed Processing and Least Cost Ration Formulation Using Excreta, and Methods of Processing and Feeding Large Animal Excreta.

Kerala Agricultural University. The plan was for one scientist to be trained in Microbiology of Aquatic Wastes, one in Microbiology of Fish Processing, and one in Experimental Methods in Animal Nutrition as Related to Aquatic Wastes. Two scientists were to be trained in Least Cost Ration Formulation.

Punjab Agricultural University. Two microbiologists were to be trained, one in Microbiology of Poultry Excreta and Pathogenic Bacteria and another in Pure Culture Technology. The training program included one scientist to be trained in Processing Poultry Excreta, and two in Least Cost Formulation Using Poultry Excreta.

Equipment Acquisition

Another major portion of the Subproject was equipment purchases for the five participating centres. A listing of the items of equipment given in the original document is given in Annex B. Funds allocated to equipment acquisition were $483,600.

b. Inputs by Government Of India.

Workshop

The G.O.I was to provide the equivalent of Rs.250,000 for costs of the workshops to be held annually.

Equipment

A total of Rs. 1,237,000 in equipment and supplies was to be supplied by G.O.I. The items are listed in Annex C.

Staff

Salaries and allowances for staff to work on the Subproject amounted to an equivalent of Rs.4,695,000.

Contingencies

The items in this category were not specified, and the total was Rs.7,128,000.

In-Country Travel

The GOI was to cover this type of travel, amounting to Rs.400,000.

2. Specification of Linked Outputs

Although not specified in the original document, the linked output would presumably be the productivity of the project, including equipment, training and the new technology developed. After the results are obtained the results would be published and technology transfer would begin.

II. Technical Assessment

A. Input/Output Progress by Objective

The objectives of the Subproject emphasized scientific aspects, hence, the inputs and outputs cannot be divided by objective. However, the inputs/outputs can be divided by function such as training, equipment acquisition, technical assistance, etc. The technical program for the next year was developed each year by the Indian Scientists at each location and the Lead Consultant.

1. Assessment of Inputs Provided

a. U.S. Inputs

The USAID inputs consisted of technical assistance, equipment acquisition and training.

Technical Assistance

The technical assistance has consisted of US scientists going to India for the Annual Workshop and activities of the Lead Consultant in the U.S. A summary of the Technical Assistance as of June 30, 1990 is given in Annex D. Of the $180,000 in the Subproject document, $113,046 had been expended. Considering that about 2 years remained in the Subproject at that time, the amount spent seems reasonable. Due to delays in the training program, planned use of other consultants was delayed. The remaining funds should be sufficient to cover the technical assistance planned in the Life-of-Project plan.

The consultants used thus far are appropriate for the Subproject. In the first year, Dr. A. D. Tillman participated in the Workshop, visited participating centers in India, and assisted with the Study Tour of the Management Team. His activities were useful since he had an important role in developing the Subproject document. Dr. J. P. Fontenot's role has been critical since he has expertise and experience in all aspects related to work in the Subproject, and is involved in all activities of the Sub-project. The visit of Dr. H. J. Gerken, Jr. was useful in planning the initiation of technology transfer activities related to the Sub-project.

Since there have been delays in accomplishing the objectives of the subproject, due mainly to delays in the training program and equipment acquisitions, it is recommended that technical assistance be provided for 1-2 years after the end of the Subproject.

Training and Project Management Tours.

The management team went to the U.S. as scheduled in spring of 1987. The persons who were to go to the US for 5 month training were scheduled to start arriving in the US in April, 1988. Arrangements had been made in the U.S. for initiation of the training program. Unfortunately, apparently due to delays in approvals and clearances at different levels in India, the Indian scientists did not begin arriving in the U.S. until June, 1989. However, by November, 1990 all of the scientists who are to go for training had gone to the U.S. except two for training and one for short-term study tour from the Toxicology Laboratory.

The training sites and programs were selected to prepare the scientists to participate in the Subproject upon returning to India. An outline of the training schedule is given in Annex E.

Equipment Acquisitions

The specifications for the equipment items were finalized in February, 1988 and are given in the Consultancy Report of J. P. Fontenot of February 26, 1988. Delays have occurred in acquisition of the equipment. The schedule of equipment acquisition is shown in Annex F. The status effective

October 3, 1990 is given in Annex G. Unfortunately, many items of equipment which were listed in the Subproject document will not be obtained. Shortening of the list was necessary due to higher than estimated prices. If funds become available certain critical items of equipment which were deleted should be purchased. The Lead Consultant would be pleased to assist in developing a prioritized list, if additional items can be purchased.

The total amount extended by USAID through June 30, 1990 was $541,000, compared to $1,339,000 in the original document.

b. G.O.I. Inputs

Many inputs have been contributed by G.O.I, but it is difficult to assess the magnitude of these inputs. The workshops have been held annually. Thus far, Rs.45,000 have been expended. There has been some in-country travel funded by G.O.I. costing Rs.188,000. Some equipment items have been purchased, especially for the Toxicological Laboratory, at a cost of Rs.1,032,000. Large amounts of staff time have been devoted to the Subproject. Thus far, the staff salaries have amounted to Rs.3,066,000. The amount spent for contingencies is not easy to obtain. Other costs including funds for vehicle acquisition, maintenance of equipment and vehicles, research operation and office equipment and supplies amount to Rs.1,957,000. The total amount spent by ICAR through March 1990 was Rs.6,288,000 compared to Rs.13,710,000 in the original document.

2. Assessment of Outputs Achieved

Based on the research which has been completed, the outputs are substantial, especially considering the delays which have occurred in the training program and equipment acquisition. An evaluation of the research outputs which have been achieved by center are given below.

Toxicological Studies. There have been delays in setting up the toxicological laboratory and getting it operational. The laboratory was moved from NDRI at Karnal to HAU at Hisar after the first year of activation of the subproject. Some activities have been initiated. Samples of milk from the HAU farm were analyzed for pesticides and some feed samples were analyzed for pesticides and aflatoxin residues (Objective 3)

Utilization of Slaughter House Wastes. Formal participation of BVC in the Subproject was delayed, apparently due to delay in approval from the State Government. However, the scientists were active in the research on slaughterhouse wastes and participating in the workshops before the participation in the Subproject was sanctioned by the State.

A summary of the research which has been conducted at BVC includes:

1) Chemical composition of blood and rumen contents. The work has included rumen contents before and after squeezing, rumen contents of different species (cattle, sheep, goats) at different seasons. (Objectives 1 and 6).

2) Use of non-toxic, non-pathogenic fungal isolates for protein synthesis from rumen contents.(Objectives 1 and 5).

3) Ensiling of rumen contents and straw with different levels of straw and molasses at different moisture levels. This was done by BVC scientists during training. (Objectives 2 and 6).

4) Urea and molasses treatment of rumen contents (Objectives 1,2 and 6).

Use of Large Animal Wastes as Animal Feed. The scientists from HAU have been very active in work on the Subproject. The research completed includes:

1) Chemical composition of dung and urine from different classes of cattle and buffaloes (Objectives 1 and 5).

2) Chemical composition and ensiling of bedding consisting of bovine waste and wheat or paddy straw (Objectives 4 and 5).

3) Ensiling of bedding (straw and waste) with different levels of green forage and molasses (Objectives 4 and 5).

4) Preservation of cattle waste by sun drying and urea treatment (Objective 3).

5) Effect of urea treatment and molasses addition on ensiling characteristics, nutritional value of and microbial destruction in cattle waste and straw mixtures. This was done by a scientist during his training program (Objectives 2,4 and 5).

6) Effect of micro- and macro minerals on growth characteristics of cellulolytic rumina bacteria (Done during training program) (Objectives 2 and 3).

Processing and Use of Aquatic Wastes for Animal Feed. Progress for the first 3 years was limited, apparently due to uncertainty of the Subproject at KAU, including delay in sending scientists for training. During the past year, level of activity has picked up. Work has been conducted on the following aspects:

1) Chemical composition of prawn processing waste (Objectives 1 and 5).

2) Ensiling of prawn waste.(Objective 2).

3) Ensiling of crab processing waste with wheat bran and maize forage. This was done by persons during their training program (Objective 2).

4) Preservation of crab waste, and ensiling with straw. This was done also by a KAU scientist during training (Objectives 1,2 and 5).

Use of Poultry Wastes for Animal Feed. The progress of the research at PAU has been very good. The research completed includes:

1) Deep stacking of a combination of wheat straw and poultry droppings. (Objectives 1 and 4).

2) Chemical and microbiological changes in poultry litter with sawdust and rice hulls as bedding. (Objectives 1 and 5).

3) Fungal biodegradation of poultry droppings. (Objective 3).

4) Changes in chemical composition of litter with time.(Objectives 1 and 5).

5) Isolation and characterization of fungal species isolated

from dried poultry droppings.(Objective 3).

6) Protein synthesis by fungi from poultry droppings. (Objective 2 and 3).

7) Deep stacking of poultry litter alone and use of the litter as livestock feed. (Objectives 2 and 4).

8) Genetic Engineering of Ruminococcus flavefaciens (Conducted during training). (Objective 3).

9) Evaluation of deep stacked and ensiled poultry litter as livestock feed (Done during training).(Objectives 1,4 and 5).

B. Progress Toward Objectives

Considerable progress has been made toward objectives of the Subproject. Results obtained thus far, indicate that development of technology to convert animal wastes into livestock feeds will enhance animal production in India. The net result will be more high quality animal protein for the Indian population. Low-value wastes, which in many instances present a disposal problem will become valuable resources.

1. Appropriateness of Objective Priorities

a. ICAR/SAU System

The objectives are pertinent for the system and in fact complement some of the efforts of the scientists in the system. This Subproject adds another dimension to the All India Coordinated Research Project on Utilization of Agricultural By-Products and Industrial Waste Materials (AICRP). In fact, for

the last 2 years the Subproject workshop was held in conjunction with the AICRP workshop. The wastes covered under the Subproject are other examples of wastes which are not being fully utilized. Some of the biodegradable animal wastes are higher in protein than the other agricultural wastes.

The subproject has resulted in the learning of new procedures and adopting of new technology by Indian scientists working on the Subproject. Examples of new procedures/technology include:

1) Ensiling for preservation and utilization of animal wastes. This is a fermentation process which can be used with a variety of products.

2) Deep stacking of low-moisture wastes. The process consists of a combination of aerobic and anaerobic fermentation. The process stabilizes the waste, destroys pathogenic organisms, and enhances the palatability of the waste.

3) Genetic engineering of micro-organisms. This powerful tool can be used to design micro-organisms capable of biodegradation of animal wastes and production of protein from the wastes.

4) Detection of pathogenic micro-organisms. These procedures will be very valuable in ensuring that the processed wastes are free of harmful pathogens.

5) Destruction of pathogenic organisms. Low-cost processes, such as ensiling and deep stacking, have potential usefulness for use on other feed stuffs.

6) Determination of toxic chemicals in feedstuffs and animal

products. The procedures will be useful for research and development of many other underutilized by-products.

7) Development of research protocols. Innovative methods include inter-disciplinary approach to planning and executing research.

8) Computer technology to record, store, summarize and statistical treatment of research data. This has included use of mainframe and personal computer technology.

9) Public institution and private industry cooperation. The Indian scientists participated in this type of cooperation in the U.S. during their training program.

10) Innovative methods of technology transfer. Indian scientists participated in technology transfer programs which have been successful in the U.S. in adoption of the technology of processing and feeding biodegradable animal wastes.

b. Indian System

The objectives of the Subproject are pertinent to the Indian tradition of maximum utilization of resources to feed an ever-expanding population. Exploiting the technology which is being developed under the Subproject would increase efficiency of utilization of resources. Some of the wastes have not been utilized, but discarded and contributed to environmental pollution.

2. Importance of US Interests

This type of project is a good example of the part U.S. scientists can play in efforts to increase quantity and quality

of food for people of the world.

a. Current

The U.S. involvement is very important for timely development of the technology to convert wastes into valuable feed resources. India has many very capable scientists involved in animal production but did not have expertise and experience in the conversion of these wastes into feeds. The training and technical assistance provided by U.S. scientists are very useful in developing and exploiting this technology in India.

b. Future

Development of cooperative work between US and Indian scientists will be helpful in improving efficiency of production of animal products, not only in India, but in the US also. An example is the planned work on safety of feeding animal wastes to lactating dairy cows. At present these wastes are not fed to dairy cows in the U.S. because of the lack of data on possible harmful residues in the milk. Solving this problem will be of benefit to food production in all countries where animal wastes are fed.

3. U.S. Role and Advantage in Cooperation

The role of the U.S. has included involvement of U.S. scientists in training of Indian scientists, technical assistance and equipment acquisition. The Indian scientists have trained at five different universities in the U.S. A number of institutions and private enterprises have been involved in the short-term study tours. An advantage has been the participation of U.S.

scientists in strengthening the effort of the Subproject. The cooperation has introduced U.S. scientists working in this area to competent Indian scientists with mutual interests. The participation of the Indian scientists in the training program has enhanced the efforts of U.S. scientists. In all instances, the trainees have actively participated in research projects at U.S. universities.

C. Progress Toward Purpose

Although the Subproject has been active for less than 4 years, and delays have occurred in the training program and in equipment acquisition, substantial progress has been made. Only limited application of the technology developed in the subproject has been adopted to increase the quantity of animal feed. However, the livestock and poultry industries are maturing rapidly, which means that increased quantities of feeds will become available from processing these wastes in the near future.

1. Relevance

a. ICAR/SAU Systems

The Subproject has provided training for scientists involved in research in biodegradable animal wastes as feedstuffs. It has also provided opportunity for these scientists to work with outstanding scientists in the U.S. in different subject matter areas. During the study tours and training programs the Indian scientists have interacted with other U.S. scientists who are not directly involved in the

Subproject activities. The trainees also had the opportunity to participate in national and regional scientific meetings and conferences. The equipment obtained under the Subproject will be useful to the Indian scientists in pursuing work in areas related to the Subproject. In most instances these equipment items were not available.

b. Indian System

The work conducted under the Subproject has already contributed toward the overall objective of increasing the quantity and quality of feedstuffs to meet the nutrient requirements of Indian livestock and poultry. For example, a limited number of Indian producers are feeding processed poultry waste. As more data are obtained, with appropriate technology transfer, it is anticipated that extensive use will be made of the technology by farmers. It is anticipated that some commercial exploitation of the technology developed under the subproject will occur. A possible scenario may be for a commercial concern to obtain and process a waste such as poultry litter, then market the processed waste alone or blended with other ingredients to the small livestock producers. The benefits of this type of industry would include increased income for the poultry producers and the transportation industry, profit for the processor of the waste, and ultimately lower feed cost for the livestock produces. The use of the waste to feed livestock would increase the amount of animal protein available for the people of India. Another benefit would be an increase in number of jobs

available.

2. Mutuality of Interests

The study tours and training programs have stimulated interest of U.S. scientists from different disciplines in the areas covered by the Subproject.

a. Current

Scientists from at least six different universities in the U.S. have interest in biodegradable animal wastes as animal feed. The subject matter expertise of these scientists are animal nutrition, microbiology and toxicology. These scientists are interested in development of formal linkages with Indian scientists. Usually, the mutual interests have resulted from associations during the training program. There is a large amount of interest in the U.S. in the technology being developed in the Subproject. The enhanced utilization of these wastes will help in alleviating pollution problems. Thus, the efforts and procedures used in this Subproject are pertinent and on the "cutting edge" of technology. Development and exploiting this technology will be of value in reducing environmental pollution. The technology will be useful to develop policy concerning environmental and human health issues.

b. Future

It is anticipated that mutual interests between Indian and U.S. scientists will increase in the future. With appropriate contacts, some U.S. scientists, in addition to those who have been involved in the training program, would likely be

interested in cooperative programs with Indian scientists.

3. Follow-on-Cooperation

The competencies of Indian scientists are sufficient for development of collegial relationships between India and U.S. scientists. This aspect was addressed in the consultancy report of J. P. Fontenot of March 19, 1990. The effort should be based on the accomplishments of the present Subproject.

a. Scientist-to-Scientist

It is recommended that a follow-up Subproject be directed toward development of colleague relationships between Indian and U.S. scientists working on biodegradable animal wastes as animal feed. It is recommended that the following areas be addressed: 1) Processing, nutrition and feeding; 2) Pathogenic microbiology; 3) Microbiological degradation and conversion of wastes; and 4) Technology transfer.

One or more Indian scientists would cooperate with one or more U.S. scientists working in a particular area. The work done in both countries would be complimentary rather than duplicative. Exchange of visits would occur at regular intervals to review progress. Some of the data from both countries may be combined for joint publications.

b. Inter-Institution

This type of cooperation may occur but the emphasis should be on the scientists, rather than the institution. There would be a formal inter-institution relationships, but only in cases where scientists from institutions in both countries will

work toward a common goal.

Perhaps, the area of conversion of biodegradable animal wastes should include the broad aspect of utilization of biodegradable animal wastes for sustainable agriculture. This type of effort would encompass a systems approach, in which alternative uses of the wastes would be explored. The alternatives could include feeding of animal wastes, direct land application and indirect land application by feeding the processed wastes, and land application of the excreta from the animals fed the waste. Such a project would be more interdisciplinary and would add agronomists and agricultural economists to the effort.

ANNEXE A
Suggested Schedule for Consultants

Year	Name	Location	Specialty	No. Weeks	Consulting activity
1	Dr. A.D. Tillman	Okla State Univ. (Retired)	Animal Nutrition	5	Advising concerning training & equipment.
1	Dr. J.P. Fontenot	V.P.I. & S.U.	Animal Nutrition & Waste Feeding	3	Review of technical program at each location, suggested training sites & equipment needs.
2	Dr. J.P. Fontenot	V.P.I. & S.U.	- do -	4	Review of research & technical program; advised on training schedule, specifications for equipment; participate in workshop.
3	Dr. J.P. Fontenot	V.P.I. & S.U.	- do -	4	Participated in All India Workshop; review research progress and technical programs, and advised concerning training.
3	Dr. J.P. Fontenot (Lead Consultant)	V.P.I. & S.U.	Animal Nutrition & Feeding Animal Waste	2	Assist in training program in U.S. & equipment purchases.
4	Dr.H.J.Gerken,Jr.	V.P.I. & S.U.	Extension animal Scientist	4	Participate in workshop, visit each participating center and advise on technology transfer concerning feeding processed animal wastes.

ANNEXE A (Continued)

Year	Name	Location	Specialty	No. weeks	Consulting activity
4	Dr. J. Minyard	Miss. State	Biochemistry/ Toxicology	4	Participate in workshop. Visit Central Toxicology Laboratory & advise on operation of Laboratory.
4	Dr. J. P. Fontenot	V.P.I. & S.U.	Animal/Nutrition & Feeding Animal Waste	4	Review research progress & technical programs at each center, participate in workshop & assist concerning processing seafood and slaughter-house waste.
4	Dr. B. White	Univ. of Ill.	Microbiologist	4	Participate in workshop and assist in research on microbial protein synthesis from poultry and cattle waste.
4	Dr. J. P. Fontenot (Lead Consultant)	V.P.I. & S.U.	Animal Nutrition & animal waste	4	Assist in and monitor training program in U.S.
5	Dr. T. A. McCaskey	Auburn Univ.	Microbiology (pathogenic)	4	Participate in workshop and assist in research on quantifying and destruction of pathogenic microorganisms.
5	Dr. J. P. Fontenot	V.P.I. & S.U.	Animal Nutrition and Feeding Animal Waste	4	Participate in workshop and assist in research on processing and feeding poultry and cattle waste.

ANNEXE A (CONTINUED)

Year	Name	Location	Specialty	No. Weeks	Consulting activity
5	Dr. B.G. Ruffin	Auburn Univ.	Extension Animal Science	4	Participate in worskhop and assist in developing technology transfer programs on feeding animal waste.
5	Dr. J.P. Fontenot (Lead Consultant)	V.P.I. & S.U.	Animal Nutrition & Feeding Animal Waste	4	Assist in and monitor training program in U.S.

ANNEXE B

PLANNED EQUIPMENT ACQUISITIONS BY USAID FOR PARTICIPATING CENTERS

NATIONAL DAIRY RESEARCH INSTITUTE

One Flame Photometer

One High Speed Centrifuge

One Colorimeter Spectronic

Two Electrical Monopan Balances

Two Micro and Ultrasonic Dissecting Instruments

One Refrigerated Centrifuge

One Beckman DU - 7

One Atomic Absorption Spectrophotometer

One Automatic Blood Analyzer

One NIR Spectrophotometer

One Laminar Flow

One Dissecting Microscope with Photographic Arrangements

One Camera for Microscope

One Polygraph

Chemicals & Glassware and Miscellaneous Items

One Fluro Toximeter

One Gas Liquid Chromatograph with Columns and Accessories, a high precision unit

One U.V. Spectrophotometer with All Accessories

One Bomb Colorimeter

BOMBAY VETERINARY COLLEGE

One "Brick" Making Unit. For preparation

of bricks from crop residues containing
rumen contents.
Three batch for tray drying units,
large size

One Large Size Press, simple design
for processing out fluid in
1st stage of drying

One Ranco Deep Freeze Unit, large size

Chemicals & Supplies

Laboratory Glassware & Crucibles &
Miscellaneous

One Combination Macro Kjeldahl
Digestion and Distillation Unit,
Electric Heating

One Large Size Hammer Mill with
Full Range of Screens

One Microcomputer with Accessories

One large Incubation Unit with
Adjustable Heat Control Unit

Reagents, Culture Materials and
Miscellaneous Glassware and Other
Small Hardware Units

Three Industrial Fermenters,
15 liters capacity

One Co Incubators, desk top size

One Atomic Absorption Spectro-photometer
with 2 lamps for each
mineral to be analyzed

One High Speed Centrifuge,
Refrigerated, laboratory size

One Photographic Camera to
fit present microscope that
has provisions for a camera

One Spectronic 20 Spectrophotometer
Range 300 - 625 nm

One Freeze Drying Apparatus

HARYANA AGRICULTURAL UNIVERSITY

One B.O.D. Incubator, large size

One Water Bath, 26 liter capacity
with open top

One Autoclave, large size

One Top Loading Balance up to 4,000 g.

Chemicals & Reagents

Glassware & Crucibles

Microbiological Supplies

One Par Bomb Calorimeter
with Accessories

One Illuminated Stereomicroscope
with Accessories

One Atomic Absorption Spectrophotometer
with 2 lamps for each
mineral to be analyzed

One Microcomputer plus Accessories

KERALA AGRICULTURAL UNIVERSITY

One Six Unit Combined Kjeldahl
Digestion/Distillation Unit

One Incubator with temperature
range from 5 to 65 C, large size

One Illuminated 100 liter
Fermentation Unit

Chemical and Microbiological
Reagents and Supplies

Laboratory Glassware & Crucibles
& Miscellaneous

One Spectronic 20 Bausch and Lomb, Spectro-
photometer with Range 340 - 625 nm

One Refrigerated High Speed Centrifuge

One Autoclave Table Top with overall
dimensions of 457 x 533 x 368 mm.

One Electronic Analytical Balance

One Laminar Flow Station, Bench top, Environmental Air Control unit.

Three Anaerobic Culture Jars with rented gas packs

One Freeze Dryer Unit

One Carbon Dioxide Incubator, large unit

One Microcomputer with Accessories

PUNJAB AGRICULTURAL UNIVERSITY

One Fermentation Unit 100 liter capacity

One Constant Temperature Water Bath, large size open top

One B.O.D. Incubator

One Refrigerator, 15 cu. ft. capacity

One Top Loading Balance, 5000 g. capacity

Reagents and Supplies for Chemical and Microbiological Researches

Laboratory Glassware Crucibles and Supplies

One Heavy Duty Grinder, electric motor driven, large size

One Rotary Shaker Unit, large size
One Electronic Balance, laboratory size

One Atomic Absorption Spectrophotometer with 2 lamps for each mineral to be analyzed

One Microcomputer with Accessories

ANNEXE C

PLANNED EQUIPMENT AND SUPPLY ACQUISITION BY ICAR

NATIONAL DAIRY RESEARCH INSTITUTE

One Flame Photometer

One High Speed Centrifuge

One Colorimeter Spectronic

Two Electrical Monopan Balances

Two Micro and Ultrasonic Dissecting Instruments

One Refrigerated Centrifuge

One Beckman DU - 7

Chemicals & Glassware and Miscellaneous Items

BOMBAY VETERINARY COLLEGE

Chemicals & Supplies

Laboratory Glassware & Crucibles & Miscellaneous

One Combination Macro Kjeldahl Digestion and Distillation Unit, Electric Heating

One large incubation Unit with adjustable heat control unit

Reagents, culture materials and miscellaneous glassware and other small hardware units

HARYANA AGRICULTURAL UNIVERSITY

One B.O.D. Incubator, large size

One Water Bath, 26 liter capacity with open top

One Autoclave, large size

One Top Loading Balance up to 4,000 g.

Chemicals and Reagents

Glassware & Crucibles

Microbiological Supplies

KERALA AGRICULTURAL UNIVERSITY

One Six Unit Combined Kjeldahl Digestion/Distillation unit

One Incubator with temperature range from 5 to 65 C, large size

One Illuminated 100 liter Fermentation Unit

Chemical and Microbiological Reagents and Supplies

Laboratory Glassware & Crucibles & Miscellaneous

PUNJAB AGRICULTURAL UNIVERSITY

One constant temperature Water Bath, large size open top

One B.O.D. Incubator

One Refrigerator, 15 cu. ft. capacity

One Top Loading Balance, 5000 g. capacity

Reagents and Supplies for Chemical and Microbiological Researches

Laboratory Glassware, Crucibles and Supplies

ANNEXE D

TECHNICAL ASSISTANCE

AMOUNT $	NAME	FUNCTION	DATE OF ARRIVAL IN INDIA	DATE OF DEPARTURE FROM INDIA	MONTHS
20,384.38	Dr. J.P. Fontenot Dr. Allen Tillman	Participant in Annual Workshop	Feb. 16, 1987 Feb. 16, 1987	March 4, 1987 March 4, 1987	1/4 1/4
14,353.93	Dr. J.P. Fontenot	Annual Workshop	Feb. 7, 1988	Feb. 27, 1988	3/4
24,620.00	Dr. J.P. Fontenot	Lead Consultant	--- Services to be in U.S. ---- 50 days		2 1/4
16,730.00	Dr. J.P. Fontenot	Workshop/visits	June 5, 1989	June 28, 1989	3/4
36,958.00	Dr. J.P. Fontenot Dr. H.J. Gerken,Jr.	Workshop/Visits Workshop/Visits	Feb. 21, 1990 Feb. 21, 1990	March 19, 1990 March 19, 1990	1 1

ANNEXE E

INDIAN SCENTISTS TO U.S.

AMOUNT $	NAME	FIELD	LOCATION	DATE OF DEPARTURE FROM INDIA	DATE OF RETURN TO INDIA	MONTHS
24.377.94	DR.M.L.PUNJ	MANAGEMENT TEAM	VARIOUS	APRIL 7. 1987	MAY 1. 1987	3/4
	DR.K.PRADHAN	MANAGEMENT TEAM	VARIOUS	APRIL 7. 1987	MAY 1. 1987	3/4
	DR.CL.ARORA	MANAGEMENT TEAM	VARIOUS	APRIL 7. 1987	MAY 1. 1987	3/4
143.171.00	DR. M.P.S. BAKSHI	ANIMAL NUTRITION	VPI&SU	JULY 6. 1989	DECEMBER 8. 1989	5
	DR. KRIPAL SINGH	ANIMAL NUTRITION	VPI&SU	JULY 6. 1989	DECEMBER 18. 1989	5
	DR. D.C. SANGWAN	MICROBIOLOGY	U.ILL.	JUNE 1. 1989	NOVEMBER 3. 1989	5
	DR. V.K. GUPTA	MICROBIOLOGY	U.ILL.	JUNE 1. 1989	NOVEMBER 13. 1989	5
	DR. P. RAMACHANDRAN	ANIMAL NUTRITION	VPI&SU	DECEMBER 7. 1989	NOVEMBER 13. 1989	5
	DR. T.V. VISWANATHAN	ANIMAL NUTRITION	VPI&SU	DECEMBER 7. 1989	NOVEMBER 13. 1989	5
23.396.00	DR. R. SIVARAMAN	STUDY TOUR	VARIOUS	OCTOBER 16. 1989	NOVEMBER 10. 1989	3/4
	DR. D.K. CHATURVEDI	STUDY TOUR	VARIOUS	OCTOBER 16. 1989	NOVEMBER 10. 1989	3/4
	DR. P.N. LANGAR	STUDY TOUR	VARIOUS	OCTOBER 16. 1989	NOVEMBER 10. 1989	3/4
	DR. VIDYA SAGAR	STUDY TOUR	VARIOUS	OCTOBER 17. 1989	NOVEMBER 10. 1989	3/4
236.379.00	DR. K.R. YADAV	ANIMAL NUTRITION	PURDUE U.	MAY 3. 1990	OCT. 3. 1990	5
	DR. M.C. GEORGE	ANIMAL NUTRITION	AUBURN U.	MAY 3. 1990	OCT. 3. 1990	5
	DR. J.S. CHAWLA	ANIMAL NUTRITION	U OF MD	MAY 17, 1990	OCT. 16. 1990	5
	DR. A.D. MERCY	ANIMAL NUTRITION	VPI&SU	APRIL 26. 1990	SEPT. 26. 1990	5
	DR. A.C. DESHMUKH	ANIMAL NUTRITION	VPI&SU	APRIL 26. 1990	SEPT. 26. 1990	5
	DR. M.B. PATEL	ANIMAL NUTRITION	VPI&SU	APRIL 26. 1990	SEPT. 26. 1990	5
	DR. K.S. SANDHU	MICROBIOLOGY	AUBURN U.	APRIL 12. 1990	Sept.12. 1990	
	DR. A.M. DAS	MICROBIOLOGY	AUBURN U.	APRIL 12. 1990	Sept.12. 1990	5
	DR. P.C. JAMES	MICROBIOLOGY	PURDUE U.	SEPT. 27. 1990		5
	DR. DR. P.M. PUNTAMBEKAR	STUDY TOUR	VARIOUS	JULY 15. 1990	AUGUST 4. 1990	3/4

ANNEXE F

SCHEDULE OF EQUIPMENT ACQUISITION

SPECIFICATION-DRAFTING AND APPROVAL BY INSTITUTIONS	- FEB-MAY 88
DARE (GOI) APPROVAL OF EQUIPMENT LIST	- MAY 26, 88
SHELADIA SUBCONTRACT SIGNED	- FEB 14, 89
IMPLEMENTATION ORDER ISSUED BY AID TO PROCEED WITH PROCUREMENT	- FEB 28, 89

ANNEXE G

EQUIPMENT ACQUISITION BY USAID

FILE NO.	ITEM NAME	PRIORITY	EST. COST	COST	DIF	CONTR VAL.	REMAINING	EST.DEL. DATE	STATUS
			$						
HAU: Budget: 45849									
BW 4	Oxygen Calorimeter	1	3975.00	3975.00	4889.25	3975.00	40959.75	Aug 15	Delivered to Inst.
BW19	Anaerobic Chamber	2	13751.00	13751.00	17542.16	13751.00	23412.59	Jul 1	Delivered to Inst.
BW 5	Analytical Balance (Consignee for 2 units)	3	1814.00	1814.00	2231.22	1814.00	23186.37	Jul 30	Warehouse
BW14	Auto Kjeldahl Analyser	5.	26214.84	26214.74	32244.13	26214.74	-11057.76	Aug 30	Warehouse
BW 6	Top Loading Balance	4	1181.87	1181.87	1181.87	1181.87	-12516.46		Supplier Cancelled Do Not Buy
NORI: Budget: 175398									
BW 1	AA Spectrophotometer & Acc.	5	29843.60	29843.60	36707.53	29843.60	138690.37	November, 30	Contracted. Pending Delivery
BW 2	HPTLC	2	51781.16	51781.16	55723.82	51781.16	82966.55	Apr 15	Delivered to Inst.
BW13	Polygraph	5	2207.93	2267.93	2789.55	2267.55	80177.00	Jun 30	Delivered to Inst.
BW 3	HPLC	3	52527.00	52527.00	64608.21	52527.00	15568.79	Jul 15	Delivered to Inst.
BW 8	US VIS Spectrophotometer	4	3100.00	7394.23	9094.90	7394.23	6473.89	Aug 30	Contracted. Pending Delivery
BW 5	Analytical Balances	9	1814.00	1814.00	2231.22	1814.00	4242.67	Jul 30	Warehouse

ANNEXE G (CONT'D)

BW 6	Top Loading Balance	8	1181.87	1181.87	1453.70				Did Not Buy
BW 9	Dissecting Microscope	6	3000.00	2957.50	3637.73				Did Not Buy
BW 4	Oxygen Calorimeter	7	7815.00	7815.00	9612.45				Did Not Buy
HAU:	Budget: 73563								
BW 1	AA Spectrophotometer and Acc.	1	29843.60	29843.60	36707.63	29843.60	36855.37	Nov.30	Contracted. Pending Delivery
BW 8	US VIS Spectrophotometer	2	3100.00	7394.23	9094.90	7394.23	27760.47	Oct.15	Contracted. Pending Delivery
BW10	Refrig. Centrifuge	3	8300.00	8300.00	1029.00	8300.00	17551.47	Jul 15	In India Delivered to Inst.
BW 5	Analytical Balance	4	1814.00	1814.00	2231.22	1814.00	15320.25	Jul 30	Warehouse
BW 7	CO2 Incubator	6	13000.50	13000.50	15990.62				Did Not Buy
BW11	Freeze Dryer	5	14137.81	14137.81	17309.51				Did Not Buy
PAU:	Budget: 47058								
BW 1	AA Spectrophotometer & Acc.	5	29843.60	29843.60	36807.63	29843.60	10350.30	Nov.30	Contracted. Pending Delivery
BW 7	CO2 Incubator	2	13000.50	13000.50	15990.62	13000.50	-2650.13	Jul 7	Warehouse
BW 6	Top Loading Balance	3	1181.87	1181.87	1453.70				Did Not Buy

BVC: Budget: 107880

BW17	Paper-Finisher Press	5	19468.65	19468.65	23946.44	19468.65	83933.56	Jul 7	Delivered to Inst.
BW14	Auto Kjeldahl Analyser	2	19468.65	19468.65	23946.44	19468.65	83933.56	Jul 30	In India
BW 1	AA Spectrophometer & Acc.	3	29843.60	29843.60	36707.63	29843.60	14981.80	Nov.30	Contracted. Pending Delivery
BW 5	Analytical Balance	4	1814.00	1814.00	2231.22	1814.00	12750.58	Jul 30	Warehouse
BW 7	CO2 Incubator	5	13000.50	13000.50	15990.62	13000.50	-3240.03	Jul 7	Warehouse
BW11	Freeze Dryer	7	5697.50	5697.50	7007.93				Did Not Buy
BW 6	Top Loading Balance	6	1181.87	1181.87	1453.70				Did Not Buy

	BUDGET	ACTUAL	REMAINDER
HAU	45949	56906.76	-11057.76
KAU	73563	74233.37	- 670.37
BVC	107880	111120.03	- 3240.03
PAU	47058	36707.63	10350.37
HDRI	175398	171155.30	4242.70
			- 375.09