BIBLIOGRAPHIC DATA SHEET

1. CONTROL NUMBER
PN-AAH-339

2. SUBJECT CLASSIFICATION (695)
AF00-2120-G352

3. TITLE AND SUBTITLE (240)

Central America: fungal fermentation of coffee waste

4. PERSONAL AUTHORS (100)

Edwards, S. S.

5. CORPORATE AUTHORS (101)

Denver Research Inst.

6. DOCUMENT DATE (110)
1979

7. NUMBER OF PAGES (120)
22p.

8. ARC NUMBER (170)
LAT663.93.E26

9. REFERENCE ORGANIZATION (130)
DRI

10. SUPPLEMENTARY NOTES (500)

(In Industrial research institutes; their role in the application of appropriate technology and development, no. 6)

11. ABSTRACT (950)

12. DESCRIPTORS (920)

Agricultural wastes
Coffee waste
Central America
Fermentation
Protein supplements
Pollution
Biomass
Waste conversion
Feeding stuffs

13. PROJECT NUMBER (150)
931009700

14. CONTRACT NO.(140.)
AID/ta-C-1337

15. CONTRACT TYPE (140)

16. TYPE OF DOCUMENT (160)

AID 590-7 (10-79)

LAT
663.93
E26

PN-AAH-339

INDUSTRIAL RESEARCH INSTITUTES:
Their Role in the Application of Appropriate Technology and Development

CENTRAL AMERICA:
Fungal Fermentation of Coffee Waste

Suellen Sebald Edwards

A series prepared by the
University of Denver
Denver Research Institute
Office of International Programs
under the sponsorship of the
U S. Agency for International Development
Office of Science and Technology

CASES IN THIS SERIES

THAILAND:
Cassava Pelletizing Technology
Ronald P Black, Wanawan Peyayopanakul, and Sachee Piyapongse

COLOMBIA:
The Composite Flour Program
James M Miller

MALAYSIA:
Small-Scale Brick Manufacturing
Ronald P Black, A Rahim Bidin, Woo Seng Khee, and Nik Ahmad Kamil

BRAZIL:
Explosive Metalworking Program
James M Miller, Jim D Mote, and Henry E Otto

THAILAND:
The Introduction of Mint Agriculture
Ronald P Black and Sachee Piyapongse

CENTRAL AMERICA:
Fungal Fermentation of Coffee Waste
Suellen Sebald Edwards

SRI LANKA:
The Ceylon Institute of Scientific and Industrial Research
Donald D Evans

THE REPUBLIC OF KOREA:
An Example of Integrated Regional Development
Donald D Evans

INDUSTRIAL RESEARCH INSTITUTES:
Their Role in the Application of Appropriate Technology and Development

A series prepared by the
University of Denver
Denver Research Institute
Office of International Programs
under the sponsorship of the
U.S. Agency for International Development
Office of Science and Technology

December 1979

This project has been sponsored through contract No. AID/ta-C-1337 with the Office of Science and Technology, Agency for International Development, U.S. Department of State. The views and opinions expressed in this report, however, are those of the authors, and do not necessarily reflect those of the sponsor.

FOREWORD

This case history has been written to assist development planners, personnel of industrial research institutes, and USAID mission personnel in understanding the role that IRIs can and do play in the application of technology to development. This case history is one in a series of eight prepared by the Denver Research Institute under the sponsorship of USAID/Office of Science and Technology (contract AID/ta-C-1337).

The cases in this monograph series first appeared in another DRI publication, Appropriate Technology for Development: A Discussion and Case Histories, edited by Donald D. Evans and Laurie Nogg Adler (Boulder, Colorado: Westview Press, 1979). This book was sponsored by the USAID Office of Science and Technology in preparation for the United Nations Conference on Science and Technology for Development (UNCSTD).

INTRODUCTION

INDUSTRIAL RESEARCH INSTITUTES

In many countries the creation of a viable indigenous industrial sector has long been considered one of the key elements to economic development. Consequently, an industrial research capability is of significance in defining the industrial needs and priorities of a country or region and matching them with appropriate technologies. An industrial research institute (IRI) has been defined as a technical organization established to make direct contributions to industrial development in the private and public sectors[1]. In this context an IRI differs from private research entities which have no proclaimed mandate or responsibility in the practical application or adaptation of technology to their countries' development needs. Frequently industrial research institutes are in some manner government funded and are therefore closely allied to the economic, social and political climate of that government. Ideally, IRIs play a supporting role in the design and implementation of national policies that reflect economic development and growth, while functioning autonomously. In reality, however, government usually plays a substantive role in research institute operations. In any case, compatibility and cooperation among government agencies should be preserved, and selection of industrial research programs should reflect needs of both the public and the private sector.

In many instances, the IRI acts as liaison between government and industry. Ideally and particularly in less developed countries (LDCs), the IRI acts as an intermediary in determination of the need for and the subsequent creation, adaptation or transfer of technology. In fact, the study of technological opportunities or the choice of appropriate technology for development is one of the major functions of the industrial research institute.

In comparison to other technologies, appropriate technology represents the social and cultural dimensions of innovation[2]. As a mediator in an innovation process, a research institute's task is to identify the real needs of the local community, develop or introduce technologies and organizational means which can meet these needs and initiate a process of development based on the internal innovative forces of the local community[3]. In this manner, the IRI addresses the issue of appropriate technology and its role in the development process.

However, opportunities for innovation do exist in areas other than just industrialization--increasing agricultural productivity, developing

---

[1] United Nations. Industrial Research Institutes, United Nations Publication No. E.70.II B.21. New York: UN, 1970, p. vii.

[2] Nicolas Jequier, Appropriate Technology: Problems and Promises. Part I, The Major Policy Issues, 1976, Development Centre of the Organization for Economic Cooperation and Development (OECD). p. 9.

[3] Ibid., p. 36.

rural technologies, and offering incentives for small industrial projects are also duties that a research institute is likely to perform.

The methods by which IRIs assess technological choice and stimulate innovation are varied. Most often development strategies would include a combination of the following:

- Survey, study and develop uses for local raw materials.
- Develop new processes and improve existing ones.
- Develop new products and recognize new uses for existing ones.
- Improve industrial and agricultural productivity.
- Study the technological and socioeconomic feasibility of industrial and agricultural projects.
- Develop standards and specifications.
- Determine choice of technology and scale of operation.
- Determine industrial location and site.
- Conduct marketing research[4].
- Acquire and disseminate scientific and technological information.
- Systems design and management of development programs.
- Evaluate a chosen technology and its relationship to local economic and cultural traditions.

To establish solutions to identifiable problems, the research institute often adapts foreign technologies to suit local conditions and offers incentives to small industries to create new technologies. Technological innovation is accomplished in a variety of ways from actual adaptation of a chosen technology to training of researchers and engineers for institution building and infrastructural support, to establishment of extension services to help define and fulfill needs.

The creation of linkages between research institutes has allowed increased communication and the transfer of information and technologies, not only between developed and developing countries, but among developing countries as well. In a few instances, regional research

[4] United Nations. Proceedings of the Interregional Seminar on Industrial Research and Development Institutes in Developing Countries, Beirut, Lebanon, 30 November-11 December, 1964. Vol. 1, New York: UN, 1966. p. 45.

institutes or networks of institutes have been established to facilitate development in common geographic and cultural areas. (ICAITI in Guatemala representing Central America is such an example.) Similarly, an international IRI organization called WAITRO (World Association of Industrial and Technological Research Organizations) has been created.

Industrial research institutes tend to become the foci for national S&T development and have offered essential infrastructural support. Research institutes, therefore, may play a very important role in mapping the future economic growth and development of a country. With this increasing responsibility, an IRI's task becomes more complex and difficult, particularly when original development goals are overwhelmed by other considerations. Factors such as politics, financial risk, societal or cultural considerations, legal restrictions, staffing problems, marketing problems, fear of change, and sheer inertia may impede or block the transfer process and thus weaken or negate its economic effect[5].

CASE HISTORIES

Much can be learned about development from the investigation and analysis of industrial research institutes. The Office of International Programs (OIP) at the Denver Research Institute (DRI) has initiated linkage activities with a variety of research institutes worldwide over the last decade under the sponsorship of USAID's Office of Science and Technology. Through these linkage activites, choice and adaptation of technology, training of researchers and engineers, exchange of information and help in the management of research institute affairs have occurred. A dynamic process of communication has been established through DRI's relationship with each research institute, and much knowledge has been gained about the development process by all those involved.

Realizing the value of imparting research institute experiences to others in the development field, DRI has gathered several case histories of industrial research institutes' endeavors in the area of technology transfer. The cases were collected for the most part by OIP staff (often assisted by IRI colleagues) who acted as impartial reporters when collecting the information. The goal of the research was not to select cases that showed only successful adaptation of technology, but to show ways and means by which IRIs must operate to encourage and achieve progress in the development scheme. There are, in fact, examples where a transfer of technology is considered unsuccessful or unsatisfactory.

The case Central America: Fungal Fermentation of Coffee Waste, written by Suellen Sebald Edwards, describes the fungal fermentation of coffee waste program under way in Guatemala and El Salvador that will result in useful protein byproducts. The cultivation of fungi on the

[5] James P. Blackledge, The Industrial Research Institute in a Developing Country: A Comparative Analysis. Washington, D.C.: USAID, 1975. p. 19.

coffee pulp juice represents a useful technological advance for LDCs--it will help to control some of the pollution involved with coffee production. This transfer of technology occurred through a collabroative arrangement between the Instituto Centroamericano de Investigatión y Tecnología Industrial (ICAITI) and the Denver Research Institute (DRI), part of these research institutes' joint linkage agreement. Partial funding for this project came from the National Aeronautics and Space Administration (NASA), who had been experimenting in converting agro-industrial wastes into animal protein supplements. The project also resulted in the formation of an international network of research institutes active in the conversion of agricultural wastes as a result of the ICAITI/DRI effort.

CENTRAL AMERICA: FUNGAL FERMENTATION OF COFFEE WASTE

Suellen Sebald Edwards

INTRODUCTION

The idea of producing a protein source for animal feed from waste is an intriguing one. To the coffee processor who has to figure out what to do with 78 percent of each coffee cherry that comes into the processing plant, the alternative of producing something useful out of waste is exciting. In Central America research has been going on for nine years to achieve exactly that--the production of protein from coffee wastes. During those nine years, various phases of work and directions have been pursued to solve one of Central America's biggest headaches--what to do with mounds of coffee pulp and how to keep rivers and lakes near coffee beneficios (processors) clean and free of pollutants. Progress has been made, and the next few years seem very promising in terms of achieving these goals.

BACKGROUND

The program for converting agro-industrial wastes into animal protein supplements began as a National Aeronautics and Space Administration (NASA) supported program, 1969 to 1973, directed toward demonstrating the technology transfer process through direct participation in the conversion and application of aerospace technology for commercial use. The objectives included undertaking additional research and development on technology available through the national space agency so that the technology could be adapted or applied to nongovernmental use, and attempting to stimulate the introduction of the technology into commercial usage by working with industrial organizations.

The Instituto Centroamericano de Investigación y Tecnología Industrial (ICAITI) and the Denver Research Institute (DRI) coupled their expertise to initiate a program of joint research, initially funded by NASA. Two objectives

were to develop useful by-products from waste materials of the coffee processing and alcohol distilling industries in Central America and to prevent pollution of water and soil by these wastes. ICAITI and DRI found that out of twenty-one cultures tested the fungal strain Aspergillus oryzae was the most suitable organism for converting coffee wastes or spent wash to mycelium, a potential food. The use of this fungus has two advantages over the use of bacteria or yeasts, also used to process wastes: (1) it appears that the wastes can be treated successfully using continuous fermentations carried out under nonaseptic conditions; and (2) the product, fungus mycelium, is filamentous in nature and can be recovered easily by coarse-vacuum-screen filtration. These two advantages mean that facilities can be built for a much lower capital cost than a bacterial or yeast fermentation plant.

Since the initiation of the project, several other fungal strains have been developed: Penicillium orustosum, Gliocadium deliquescenus, Trichoderma harzianum. All of these strains are being used in the current research project.

The project also resulted in the formation of an international network of research institutes active in the conversion of agricultural wastes. The consortium included: Federal Institute of Industrial Research (FIIR), Nigeria; (ICAITI), Guatemala; Instituto de Investigaciones Tecnológicas (IIT), Colombia; Instituto Nacional de Tecnologia, (INT), Brazil; Instituto de Tecnologia de Alimentos (ITAL), Brazil; and DRI, United States. Several newsletters were published by DRI containing research results from the participating institutes and were distributed through the network.

CHOICE OF THE SUBSTRATE

Coffee-processing waste water was chosen specifically as the substrate for growing biomass. An understanding of how coffee is processed in a typical beneficio will illustrate some of the unique problems that Central America has to solve.

The processing of coffee fruits, which involves the use of large amounts of water that become high in organic matter content, yields 4.5 tons of wastes (which can be useful or nonuseful) for each ton of dehulled coffee. In some beneficios, such as in El Salvador where fresh water is scarce, plants are centralized and the process water is recycled several times, thus producing an even greater pollution concentration in the waste water. These waste waters are often put into evaporation ponds where aerobic digestion and bad odors develop.

Coffee processing typically involves the following steps (see Figure 1):

(1) Coffee berries are dumped into a receiving tank of water.

(2) Coffee berries that float are channeled to separate processors, for they are of inferior quality. The berries that sink are transported with water to the pulpers, where the pulp is separated by mechanical action.

(3) The de-pulped berry (grain and mucilage) is sent to a fermentation tank. (The partially pulped or unpulped berries are recycled back to the mechanical pulper.)

(4) The grain is kept in the fermentation tank without water for several days, allowing for the natural biodegradation by coffee enzymes and microflora and thus removing the mucilage.

(5) After fermentation, the coffee grain is washed in water channels, where the grains that float are separated from the grains that sink.

(6) The washed grains are put on large cement or tile drying patios, where the moisture is evaporated by solar energy (during this time the grains are "raked" to ensure even drying).

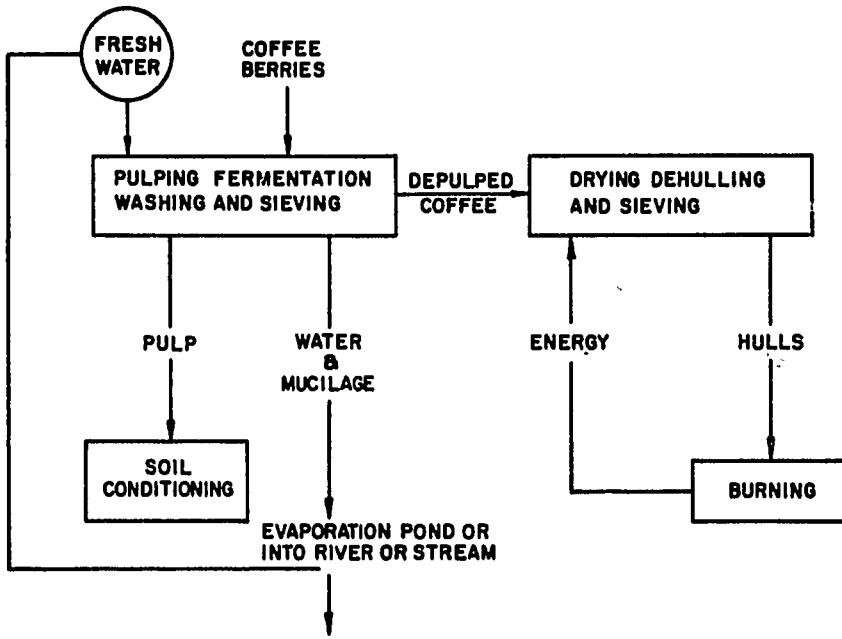
(7) The grains, when they reach a critical level, are transferred to dryers, where moisture is reduced to about 10 percent.

(8) The dry grains are then dehulled mechanically.

(9) The result, green coffee, is bagged and shipped to consumers

Two factors led to the decision to use coffee-processing waste water as the substrate: the increase in contamination caused by those "wastes," and the growing need for food. Thus, development of a process that would combine treatment of effluents from coffee processing with controlled growth of biomass was chosen as the best option. The ultimate objective was to develop a simple, nonaseptic, continuous fermentation system that could be installed at beneficios. It was believed originally that the biomass production would cover the cost of water treatment.

FIGURE 1
PROCESSING OF COFFEE BERRIES



Source "Protein from Waste: Growing Fungi on Coffee-Waste", Chemtech (October, 1976): 637.

The project began with the selection of adequate strains from shake flask experiments. Microorganisms were screened and selected according to their chemical oxygen demand (COD) consumption, nutrient requirements, and growth. Promising results were obtained using various designs of bench-scale fermentors under nonaseptic conditions in both batch and continuous processes. Rat-feeding studies were undertaken at ICAITI to compare the growth rate of rats fed the protein supplement with rats fed commercial protein. Preliminary results showed that the product was nontoxic and that the rats grew at approximately the same rate as those not fed the biomass.

The development of biomass from unsophisticated procedures in a developing country is viewed as a significant achievement by the project leaders. Usually this experimentation takes place with costly, sophisticated equipment; it was rewarding to the researchers to have success with bench-scale fermentors under nonaseptic conditions in both batch and continuous culture.

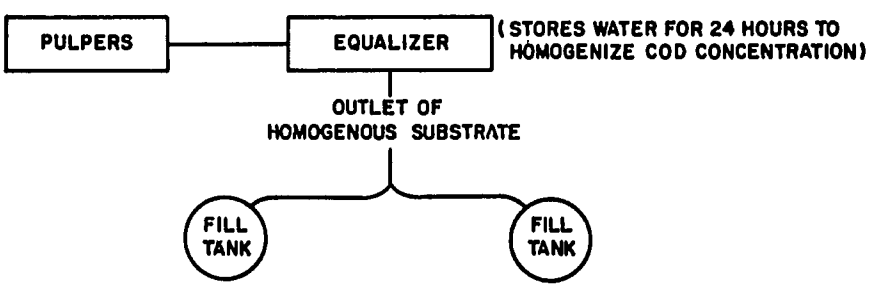
PILOT PLANT -- 1974-1975

Next came the design, construction, and operation of a pilot plant fermentation unit in El Salvador, beneficio Curazao. ICAITI sent personnel to work at and to supervise the building of the plant; the beneficio contributed by providing labor, building concrete tanks, and purchasing an air compressor. The beneficio was interested in working with ICAITI and in utilizing the process for producing biomass. The fact that the process would significantly reduce the COD content of the waste water was only a side bonus and not the main concern of the beneficio.

The pilot plant consisted of a 2,000-gallon equalizing tank, two 5,000-liter fermentors, and two 450-gallon seed fermentors (see Figure 2). An equalizer was needed because the nature of the coffee pulp depends on the time of year and the altitude at which the coffee cherries are picked: those picked at lower altitudes have less water, as do those picked near the end of the coffee season, when the atmosphere is very dry. Thus, the substrate varied greatly with the amount of water in the cherry pulp. Controlling the substrate would have involved changes in the beneficio process, for the volume of water and of coffee processed fluctuated widely.

The waste water entered the pilot plant via a sedimentation tank, where large, suspended particles were removed, and continued through the equalizer (for twenty-four hours). The fili tanks received the substrate, with nutrients added according to the carbon/nitrogen/phosphorus ratio. The inoculum, a 450-gallon culture of T. harzianum, was produced nonaseptically for twenty-four hours on a 2 percent blackstrap molasses supplemented with phosphoric acid and ammonium salts. The pH was adjusted to 3.5 with sulfuric acid.

FIGURE 2
PILOT PLANT FOR WASTE WATER TREATMENT



The pilot plant operated for one coffee season (six months) under nonaseptic conditions (which was possible due to the high acidity of the waste), resulting in good fungal growth. However, the amount of protein was low; therefore, it was difficult to recover the biomass because it was so dilute.

Several factors contributed to the decision by the beneficio to terminate the pilot plant after only one season. One reason involved the economics of recovering the biomass. When calculations were made for the scale-up to production level, it was shown that the biomass recovery and drying were too expensive compared to the price at that time of soya and fishmeal feed supplements; they were selling at the same price that it would cost to market the coffee waste biomass. Second, additional research was necessary to solve some of the recovery and drying problems before a marketable product could be produced. The beneficio was unwilling to contribute financially for further research. The El Salvadoreans were disappointed in the whole experiment. ICAITI may have partially contributed to the disillusionment by not explaining well or making clear from the start the nature of a research project, i.e., that when the pilot plant operations were over, there would be no guarantee of a biomass-producing-plant blueprint. Third, the process water being used by the beneficio was contaminated. Whether this affected the animal feed was not determined; additional tests would have been necessary. The process reduced the COD content in a significant way, so the process was cleaning the water, but this was not of interest to the beneficio (no government regulations existed at that time regarding water pollution).

Efforts to encourage other Central American funding agencies to continue the project were not successful, mainly because of the unique characteristics of El Salvadorean coffee beneficios. El Salvador, unlike other Central American countries, has large, centralized coffee beneficios. In addition, they utilize scarce water resources by recycling the water through the processing plant, resulting in a large concentration of wastes in the discharge water. Because the results of the pilot plant project were not transferable to other beneficios with other production methods, the alternative sources for funding were not interested in continuing the project.

At this point, the project leaders went "back to the drawing boards" and reviewed the direction of the project. Discussions were held to decide whether the project should choose a different substrate. The answer was "yes."

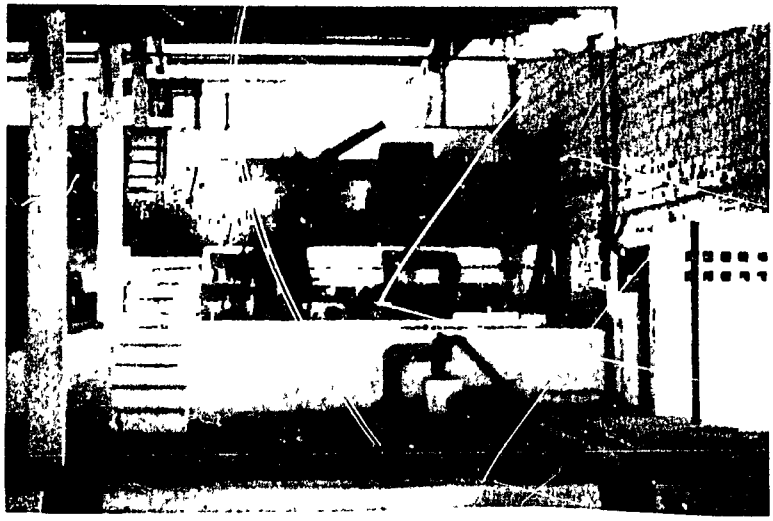
SWITCH TO ANOTHER SUBSTRATE TO PRODUCE BIOMASS

Because of the high viscosity of the mucilage (mainly composed of pectin, carbohydrates, and water) and the fact that aeration is difficult except by adding water, it was decided not to use mucilage as a substrate. (Recovering the pectin is the only use for the mucilage, and this research already is being done throughout Central America.) Also, ICAITI spent eight months working on laboratory fermentations of the mucilage and of combinations of mucilage and sugarcane molasses. The preliminary economic analysis showed that the substrate was not practical; it was recommended that ICAITI fund something else.

In July 1976, ICAITI began working with the coffee pulp. Coffee pulp comprises a major portion of the cherry and is thrown away immediately after the berries are depulped at the beginning of the production process. Several methods have been tried to find a use for the pulp. Traditionally, the pulp has been used as a fertilizer or compost. It also can be ensiled and used for animal feed bulk. (Research by a Central American nutrition foundation, INCAP, has found that 20 to 25 percent pulp is the maximum amount that can be added to animal feed.) Ensiling involves storing the pulp in silos, where it is compressed manually to remove all oxygen, and keeping the pulp in the silo for one year, after which it can be used for animal feed. This solution creates storage costs and runs the risk of producing toxic animal feed, for unless all the air is squeezed out, pockets of aerobic digestion will occur resulting in fungal growth or alcohol formation. If the coffee pulp is left in large piles, aerobic digestion begins immediately, fouling the air, plus the pile squeezes the pulp on the bottom, causing the pulp juice to permeate the soil and eventually contaminate the water surrounding the beneficio.

Because aerobic fermentation begins as soon as the pulp is dumped into the mound, ICAITI's researchers decided to press the pulp and use the pulp juice as the substrate. The juice is homogeneous, consisting of carbohydrates and 5 percent sugar--seemingly an ideal source. Also, because all Central American coffee beneficios have the same process for removing the pulp, the results would have universal application, unlike the original substrate. Since the second quarter of 1977, ICAITI has been testing the pulp juice with the same fungi used with the waste water. The tests have been encouraging: the fungi grew well and consumed the carbohydrates (80 percent).

In 1978 ICAITI researchers started a new fermentation process, stopping the fermentation before all the carbohydrates had been consumed. This resulted in carbohydrates and biomass, which were concentrated to a syrup.



Coffee cherry depulpers and fermentation tanks
at a coffee beneficio in Guatemala

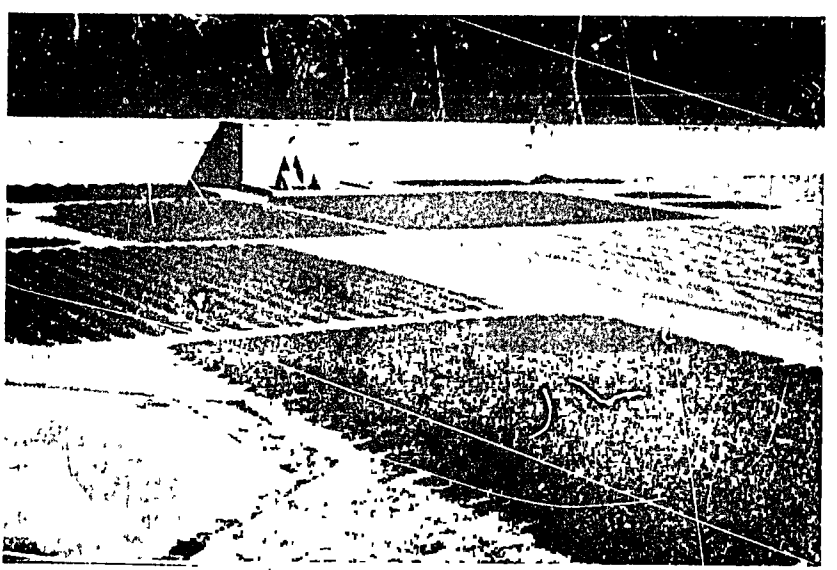
Coffee waste pile at a large beneficio in Guatemala,
to become compost or animal feed supplement

The reasons for concentration were threefold: (1) to separate the fungi required a filtration energy; (2) to preserve the fungi required drying and thus greater amounts of energy; and (3) the concentration procedure was a one-time cost; it also resulted in a low-water-activity product, thus retarding the growth of yeast. Thus, the syrup could be stablilized without refrigeration, and the coffee juice molasses could be mixed with feed to enrich the protein content.

Tests at ICAITI with a 500-liter tank will provide enough data for market studies to be completed by 1980. Also, the switch to pulp juice has benefits in terms of the size of the market. The Central American beneficios all have the same process for removing the pulp, and all have the problem of what to do with the pulp. The low viscosity of the substrate makes it excellent for fermentation.

SECOND PILOT PLANT -- 1978-1979

A pilot plant is being installed at beneficio CAFOSA in El Pino, Guatemala, to test the coffee pulp juice substrate program (see Figure 3). The technology of the U.S. citrus industry, a continuous screw process, purchased with OAS money (a Vinzent machine, costing $17,000) is to be installed by August, in time for the coffee season (September-March). The output is one and one-half tons per hour. The pilot



Large open-air drying patio for coffee beans

plant, with the continuous press, will accommodate large beneficios; the alternative of a hydraulic press for smaller beneficios, yielding smaller outputs, is being studied at ICAITI.

The question of economy of process is still a problem. The following facts have to be considered:

(1) The coffee season is from September to March; therefore, two alternatives may be considered when a decision is to be made on how to complete an economic feasibility study (one year of fermentation data is needed).

   (a) Alternative 1: When the season ends, use another substrate, e.g., sugarcane molasses.

   (b) Alternative 2: Have pressing capacity higher than fermentation capacity, concentrating coffee pulp juice and storing it for year-round use.

(2) ICAITI is gambling that the biomass will be economically feasible with current prices of livestock feed.

   (a) ICAITI has studied many processes for producing single-cell protein (SCP), and a large percentage of the cost was for the raw material.

   (b) However, ICAITI is utilizing a substrate that is a waste from coffee production. The product is looked upon as a savings.

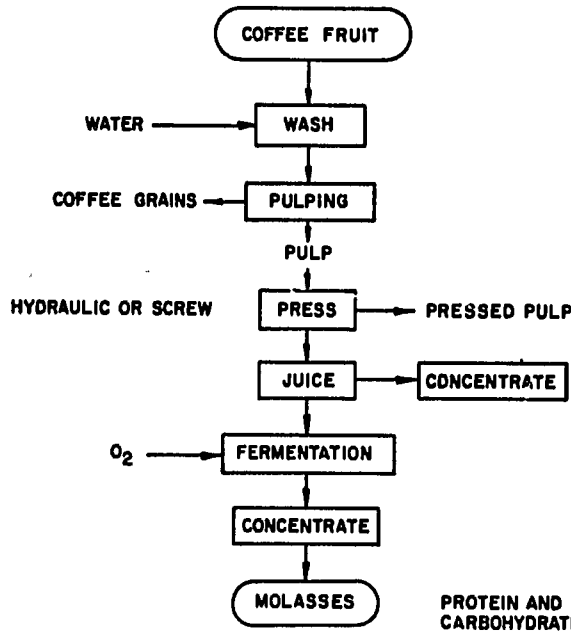
   (c) Other processes utilize sophisticated, aseptic processors. ICAITI will utilize inexpensive, unsophisticated materials and equipment, the major expense being the aeration equipment and energy requirement. The process is nonaseptic.

(3) ICAITI has not tested any yields from a continuous press, nor any yields from the substrate--it has only initial test results. Thus, the project is operating with hope.

IMPACT

The impact of the coffee pulp fermentation project is hard to assess at this point, for long-term results are

FIGURE 3
PILOT PLANT FOR COFFEE PULP JUICE PROCESSING



nonexistent. However, the impact will be felt in several areas.

To the campesino, the biomass will add value to the coffee crop; hopefully, this value will be reflected in the price that the beneficio will have to pay for the crop. The livestock producer will have a greater availability of protein sources that hopefully will be less expensive than those currently available. This project also will have an impact on energy consumption for protein production. Because the protein will be produced from waste, the impact versus output will create a balance.

Impact on employment generation will be felt, assuming that the pilot plant design is successful. Beneficios can have the system installed (with two or three crop seasons of technical assistance from ICAITI) and can utilize five people for its operation. This reflects a 10 percent increase of total labor for an automated beneficio. Finally, there is and will continue to be an impact on the contribution to scientific knowledge. Many scientific papers, distributed worldwide, have resulted from the project and have created much interest in the process. They also have contributed to a body of literature that was very small.

ECONOMIC ASPECTS

It is difficult to determine exactly how much money has supported and is supporting this project, because ICAITI contributes what is not provided by OAS funds; this amount varies from month to month. Support from outside ICAITI for the past five years has varied in amount and source. The OAS contributed $45,000 in 1974; the current budget includes $35,000 from OAS. The Regional Office Central American Program (ROCAP) of the Agency for International Development (AID) contributed to the project until 1975; this support totaled approximately $7,000. The money contributed by OAS was spent on equipment, materials, and some salaries.

SPIN-OFFS TO THE ORIGINAL PROGRAM

The program has created wide interest among coffee growers, processors, associations, and various individuals. The interest from these groups is not exclusively for biomass production but also for waste water treatment and methane generation. Professors and biologists also are asking to be trained in the technologies at ICAITI. This interest has been generated by word of mouth, through ICAITI's participation in coffee associations, and through the publication of scientific articles.

Examples of this interest are as follows:

(1) After ICAITI made a presentation of current research projects at the National Coffee Growers Association of Guatemala (ANACAFE), growers from El Tumbador, Guatemala, requested a presentation of technical innovations for by-products of coffee waste.

(2) Brazil, Venezuela, Costa Rica, and El Salvador have asked to have people trained in ICAITI's microbiology laboratories.

(3) Through the Coffee Research Center in Costa Rica (CICAFE), information on ICAITI's research results and projects will be disseminated, creating awareness by a very large group of enterprises.

(4) A Costa Rican beneficio is asking the Costa Rican Development Bank (CODESA) to invest in a $2 million plant to convert the coffee pulp juice into a useful product. ICAITI has been approached to provide research and technical assistance.

(5) Several beneficios in Guatemala have approached ICAITI to provide them with technical assistance for cleaning up their waste water. Even though waste water regulations are not enforced in Guatemala, some communities are bringing suit against the beneficios, and they are turning to ICAITI.

REFERENCES

Aguirre, F. et al. "Protein from Waste: Growing Fungi on Coffee Waste." Chemtech (October 1976): 636-642.

Church, Brooks, and James P. Blackledge. "Extending the Universities' Role in the Exploitation of Aerospace Technology." Final Report to NASA, Grant No. NGL 06-004-096. Denver: Denver Research Institute, April 1974.

Dengo, J. Gabriel. Production of Fungal Protein in Lesser Developed Countries. Denver: Denver Research Institute, August 1973.

Espinosa, R., B. Moldonado, J.F. Manchu, and C. Rolz. "Aerobic Nonaseptic Growth of Verticillium on Coffee Waste Waters and Cane Blackstrap Molasses at a Pilot Plant Scale." Biotechnology and Bioengineering Symposium 7 (1977): 35-44.

"Fungal Treatment of Agricultural Wastes for Water Re-Use and Conversion to an Animal Feed." Denver: Denver Research Institute Invitational Conference, 16-17 August 1973.

PERSONS INTERVIEWED

Francisco Menchu, project leader, ICAITI

Cheryl Schneider, biochemist, ICAITI

Roberto de Leon, biochemist, ICAITI

Francis Aguirre, division head, ICAITI

Ricardo Garcia, project investigator, ICAITI

Oscar Maldouado, electrical engineer, ICAITI

Rodolfo Espinosa, Destiladora de Alcoholes y Rones

Three beneficio managers