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9. ABSTRACT
The objectives of this report are to introduce the climate, geography economy, and people of Panama and with this descriptive perspective to present the results of an A.I.D. survey of agricultural by-products and wastes. The survey is meant to be qualitative, descriptive, and quantitative so that each waste or by-product is placed in the proper perspective as to size, location, and problems. To examine the potential means for utilizing the most promising waste materials in the animal industry of Panama the report attempts to examine the current size of the industry and the current status of supply of other feeds. Production of cattle, swine, and poultry in Panama could be significantly increased if means could be found to use sugar cane, banana, and rice processing waste as animal feed. Almost 30% of the bananas harvested are rejected for poor quality. Although poultry manure is not available in as large an amount as banana waste, its high nitrogen content makes it a valuable material in a country where nitrogen is scarce. Molasses is a good carrier and trap for the ammonia nitrogen in poultry manure. A study should be done of the economic feasibility of using excess sugar cane bagasse as an absorbent or carrier for molasses and additional minerals and vitamins in a pelletized animal feed. The production of single-cell protein in Central America faces several important constraints. The agricultural industry in these countries cannot support the high technology processes for production of single-cell proteins. Relatively

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simple processes for extracting chemicals from agricultural wastes need to be developed. The recommendations are considered in terms of the resources and capabilities of Panama. This includes the establishment of a rationale and a set of criteria for the implementation of specific recommendations. The recommendations are summarized.

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FINAL TRIP REPORT ON A VISIT TO PANAMA TO SURVEY THE UTILIZATION OF AGRICULTURAL WASTE FOR ANIMAL FEED

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FINAL TRIP REPORT ON A VISIT TO PANAMA TO SURVEY THE UTILIZATION OF AGRICULTURAL WASTE FOR ANIMAL FEED

Charles L. Cooney and Charles Dunlap

1.0 INTRODUCTION

1.1 Origin of Trip

The origin of our visit to Panama began with a request to the Office of Nutrition, U. S. Agency for International Development, for a consulting team to visit Panama and survey the potential utilization of agricultural waste for animal feed. This request was passed on to Dr. Samuel M. Weisberg, Executive Director of the League for International Food Education (LIFE), who contacted Dr. Charles L. Cooney of the Massachusetts Institute of Technology in his capacity as Chairman of the Liaison Committee between LIFE and American Chemical Society Division of Microbial Chemistry and Technology. From these sequences of contacts a team of two consultants, Dr. C. L. Cooney and Dr. C. E. Dunlap, was sent to Panama under the sponsorship of AID. Dr. Cooney is an Assistant Professor of Biochemical Engineering in the Department of Nutrition and Food Science at MIT and has experience in single-cell protein production, fermentation processes including the use of waste products and enzyme technology. Dr. Dunlap is an Assistant Professor of Chemical Engineering at the University of Missouri and has experience in the processing and conversion of cellulosic materials into protein products and bioprocessing technology.

1.2 Purpose of Trip

The overall objective of this trip was to survey the sources of agricultural waste in Panama and examine their potential for use in animal feeding. There was specific interest in the utilization of sugar cane, banana processing, and rice processing waste. During the trip every effort was made to talk to responsible and representative individuals in both the private and public sectors. This included discussion with people in Panama City as well as trips to the interior to visit the sites of waste generation and potential sites of utilization, e.g., centers of high animal density. In many cases, we sought to speak separately with several groups active in the same field to obtain as complete a picture as possible from several points of view.

Our specific objective was to compile a list of recommendations identifying specific waste materials which could be used (in the context of Panama) for animal feed either with or without further processing. Futhermore, these recommendations were to be based on an analysis of both the sources and the points of utilization of the wastes.

1.3 Objectives of Report

The objectives of this report are severalfold. First, the introduction is intended to place our trip and the country in perspective. An analysis of the trip followed by specific recommendations would be of limited value without some insight into the country itself, its climate, geography, economy, and people.

Having established a descriptive perspective of Panama, the second objective is to present the results of our survey of agricultural by-products

and wastes. This survey is meant to be qualitative, descriptive, and quantitative such that each waste or by-product is placed in the proper perspective as to size, location, and problems.

The next step is to examine the potential means for utilizing the most promising waste materials in the animal industry of Panama. To do this we have attempted to examine not only the current size of the industry but also the current status of supply of other feeds. This information is then placed in perspective by examining in detail the possible utilization of the most promising waste materials.

The recommendations which evolve from the above presentation are considered in terms of the resources and capabilities of Panama. This includes the establishment of a rationale and a set of criteria for the implementation of specific recommendations. Lastly, the recommendations are summarized.

1.4 Overview of Panama

1.4.1 Basic Statistics

The Republic of Panama is a narrow isthmus of 29,209 square miles running east-west along the latitude 9° north of the equator. It is bordered on the west by Costa Rica and on the east by Colombia. Mountains form a central backbone along the total length of the country broken only at the central Panama Canal. Costal lowlands extend from the mountains to the coasts on both the north (Caribbean) and south (Pacific) sides.

The climate is tropical with year-round temperatures averaging about $81^{o}F$ except for the cooler mountains. Seasons and rainfall are controlled by

the prevailing winds which are from the Pacific from April through September (the wet season) and from the Atlantic from October through March (the dry season). Rainfall on the Caribbean slope averages 150 inches per year and is more-or-less equally spaced throughout the year. The Pacific (south) slope, however, receives about 85 inches per year of rainfall which occurs principally during the wet season.

Current population is about 1,500,000. Major ethnic groups are: mestizo 65%, negro 13%, white 11%, indian 10%, oriental 1%. The population growth rate of about 3.0% per year is lower than that for most other Central American countries. Urban areas hold 42% of the population and rural areas 58%.

Since 1968 Panama has been under a relatively stable military government and the operating federal agencies or Ministries of the Republic are intact and functioning (i.e., Agriculture, Health, Industry, etc.).

1.4.2 Economy

Panama's 1970 GNP was $755 million. Agriculture, forestry, and fishing accounted for 21.7% of the GNP: manufacuring (chiefly food processing) 16.3%: services 24%; commerce 14%; and the remainder from other sectors.

The United States is Panama's most important foreign trade partner. The U. S. imported about $50 million worth of Panamanian goods during 1972 while exporting over $250 million worth of materials to Panama. Table 1 shows that the bulk of U. S. imports are agricultural and fisheries products.

The nonagricultural sector of the economy includes the considerable impact of the Panama Canal. Commerce generated and services utilized by the Panama Canal Co. and its employees runs over $100 million per year, or 35% of the commerce and services of the country. Manufacturing other than food

processing is limited to the Texaco petroleum refinery near Colon, a cement processing plant, and other--considerably smaller--industries. Minerals and mining are undeveloped but a copper deposit is being investigated for possible future development by an outside company.

Table 1

U. S. IMPORTS FROM PANAMA, 1972

Import	Value ($x10^6)
Bananas	16.1
Shrimp	12.5
Oil Products	7.85
Sugar and Molasses	7.1
Beef	2.6
Fish (edible)	1.42
Hormones (synthetic)	1.2
Lobster Tails	0.35
Coffee	0.35
Cocoa Beans	0.29
Salt	0.09
Lumber	0.038
Rubber	0.023
Plantains	0.022

The agricultural sector of the economy including fishing, and food processing and refining provides by far the largest part of the GNP. Tables 2, 3, and 4 show 1972 or 1973 crop, fish, and animal production in the country. Bananas are by far the largest export of the country in both tonnage and value. Fisheries products are second followed by sugar and molasses, beef, and smaller amounts of coffee, cocoa, and other products.

Trade in agricultural products within the country is regulated by the government through a stringent set of price controls designed to keep consumer prices low and as much in line as possible with the low buying power of the people. Controls on agricultural or fisheries exports are also strict and many industries (fishmeal, beef, sugar, rice, etc.) are required to sell a considerable fraction of their output within the country at a low, controlled price. On the other hand prices to be paid small farmers for their produce are also set, and processors are usually required to buy the total internal supply of these commodities often at prices above the world market. Profits to processors are squeezed by these controls and most are apathetic about expansion. The problem of controlling inflation in a tropical country of few developed (or available) natural resources is very difficult and the government cannot be faulted for its attempts.

Agricultural land distribution is such that a few companies or individuals own or control a majority of the land area with many small farmers operating only one to ten acres. The use of borrowed capital for financing farm improvements follows the same pattern. The large farmer or company can justify and receive needed funding while the small farmer finds it difficult and often does not want to put himself in a debt position.

Table 2

CROP PRODUCTION: PANAMA, 1972

Crop	Units	Acres	Production	Imports	Exports
Rice	U. S. Ton	259,500	138,030	6,100	-
Corn	U. S. Ton	162,300	48,900	21,750	-
Beans	U. S. Ton	25,450	3,440	(+)	-
Sugar Cane	U. S. Ton	73,000	1,491,000	-	-
Molasses	U. S. Ton	-	37,200	-	(++)
Raw Sugar	U. S. Ton	-	33,000	-	(++)
Refined Sugar	U. S. Ton	-	108,000	-	(++)
Oranges	U. S. Ton	10,000	33,740	-	(++)
Bananas	U. S. Ton	55,000+	275,000+	-	219,000
Plantains	U. S. Ton	(+)	(+)	-	-
Coffee	U. S. Ton	(+)	5,000	-	1,000

(-) Data unavailable

(+) Indicates some positive quantity

(++) Indicates an appreciable fraction of the total

Table 3

FISHERIES PRODUCTION: PANAMA, 1972-1973

Resource	Units	Catch	Exports
Shrimp	U. S. Tons	6,100	(++)
Anchovies	U. S. Tons	38,029	(To meal)
Herring	U. S. Tons	15,776	(To meal)
(Fishmeal)	U. S. Tons	15,400	9,200

(++) Indicates an appreciable fraction of the total

Table 4

ANIMAL PRODUCTION: PANAMA, 1972-1973

Product	Units	Herd	Annual Production	Imports	Exports
Chickens	Head	3,706,000	-	(+)	-
Eggs	-	-	-	-	-
Swine	Head	187,500	65,000	-	-
Pork	U. S. Tons	-	-	94	-
Cattle	Head	1,312,000	202,000	-	(+)
Milk	-	-	-	-	-
Goats	(Not in commercial quantity)				
Sheep	(Not in commercial quantity)				

(+) Indicates some positive quantity

Fertilizer is also in limited supply, all fertilizer is imported, and high world market prices limit its use to such crops as sugar, bananas, and rice so per-acre productivity for large farmers is usually higher than that for smaller farmers.

2.0 SURVEY OF AGRICULTURAL BY-PRODUCTS AND WASTES

All developed agricultural land is in the western half of the country and all except one area devoted to bananas is on the south or Pacific side of the central mountains. The two major rice producing areas are around the city of Penonome and in Chiriqui province near David. Sugar cane is grown in the 40-mile strip between Santiago and Aguadulce in or near the drainage of the Rio Santa Maria. Bananas are cultivated by the Chiriqui Land Company in two divisions; the Bocas del Toro division in the northwestern part of the country and the Chiriqui division near Puerto Armeulles in the southwest. Citrus and coffee are cultivated in the higher regions near Boquete in Chiriqui province. Most vegetables, some pineapples, and most corn is also grown in Chiriqui province which has the best agricultural land in the country. Poultry and swine are raised in Chiriqui province and around Panama City. Cattle are pastured in almost all areas between David and Panama City with five or six very large ranches in eastern Chiriqui and western Veraguas provinces. The only cattle feed lot of any scale in Panama is quite new and is located near David. Most fisheries and all fish processing plants and fishmeal plants are in the Panama City area.

Wastes generated by agriculture will be considered on the basis of each crop or industry. We will attempt to characterize the location, amounts.

quality, and present uses (or lack of uses) for each waste along with other data pertinent to its possible use as an animal feed.

2.1 Banana Processing

Bananas are the largest single export in Panama and production is carried out in two locations both of which are primarily under the direction of the Chiriqui Land Company. The first location is in Bocas del Toro, an area on the Northwest Coast bordered by Costa Rica on the west side. The area is inaccessible by land and all materials are taken in by air or sea. The second location is in Chiriqui province around the port of Puerto Armuelles. This area faces the southern coast of Panama and is bordered on the west by Costa Rica. Unlike Bocas del Toro, the area is accessible by land as well as sea. Each area has its own endogenous railway system for transportation of bananas from collection center to dockside. While these railway systems provide good transportation within each area, they are not linked to any other areas. In fact, the only other developed rail system parallels the Canal.

The Chiriqui Land Company owns most of the banana producing lands but does lease out areas to a number of smaller, independent producers. The company in turn purchases all of the acceptable bananas produced by the independents and provides guidance for production and land care.

Banana production is labor intensive and employs a large number of people to maintain the fields, cut and transport the harvested fruit, sort, clean, and box the fruit, and finally load it onto ships for transport. All of these operations, cutting to shipping, must take place within 36 hours to insure quality fruit at its final destination.

There are several wastes and by-products from banana processing. The banana tree always has three stems, each at a different stage of growth, so that banana harvest takes place almost continuously (while harvest proceeds throughout the year, in Bocas del Toro, December-January and June-July are such periods). At harvest the stalks containing the bananas are removed and sent by an overhead cable to one of 31 sorting and boxing centers. The stem (about 10-12 feet long and 6-8 inches in diameter) is cut and left in the field along with the leaves. These materials will completely rot within 8 months. The following table gives approximate weight percentages for the banana tree:

Component	% of Total Weight
Fruit (fruta)	17
Leaves (hojas)	5
Stem (tallo)	75
Fruit stalk (pimzote)	3

Only the fruit and stalk, which comprise 20% of the total weight, leave the field. Removal of the leaves and stem would be physically difficult and futhermore would require a greater addition of minerals back to the land.

Once the fruit and stalks arrive at the sorting station, the banana bunches are cut from the stalk. The stalk is thrown into a trailer and the fruit is sorted into first, second, and rejected grades. Most of the rejected fruit is due to fruit size and skin blemishes. The rejects are then tossed into the trailer with the stalks. The stalks and most the rejected fruit from the 31 stations at Bocas del Toro are taken to one of four dumps.

An important point to note at Bocas del Toro is that approximately 40% of the rejected fruit is taken to a puree plant. However, even with

the use of only a fraction of the waste bananas, it is possible to meet the current puree market.

The approximate production figures for Bocas del Toro and Puerto Armuelles are 15 x 10^6 boxes shipped from each location per year. Each box contains about 40 pounds. Therefore, the total shipment from Panama is 30 x 10^6 boxes or 1.2 x 10^9 lb./yr. of waste banana and only 20% of this total is used for puree, so that 4.1 x 10^8 lb./yr. (2 x 10^5 tons/yr.) are available as waste; 2.6 x 10^8 lb./yr. are centrally located at Bocas del Toro. A small portion of these wastes are currently fed to local animals. possible 1-2% go to pig farmers and some to cattle farmers (in Bocas de Toro, there are an estimated 5000 head of cattle: the total population is about 25,000-30,000 people).

The banana market is a sensitive market in terms of fruit quality and price. If bananas are not near perfect, they are not sold. The selection at the site is critical. If bananas are too expensive, then the quantity sold falls. In most of the world bananas are a luxury food and are purchased when the price is low. Early this year a banana tax was to be imposed on all expected fruit. This tax would substantially increase the price and, as a consequence, there may be even more waste bananas in the future.

2.2 Sugar Processing

The production of centrifugal cane sugar from sugar cane results in several by-products and wastes. The cane is first cut in the field and piled in windrows, which are burned to remove the leaves and leafy tops from the stalks. The stalks are transported to the mill where they are chopped and fed into a train of extraction rolls where the juice is expressed. The fibrous roughage or bagasse exiting the mill-rolls is transported either

to the mill furnaces to be burned for steam production or to a storage yard. The raw cane juice is clarified by a lime treatment followed by filtration. The solids left on the filter are called filter mud or cachassa and are conveyed to a cart for redistribution on the fields. The clarified juice is then concentrated and crystallized. The sugar crystals are removed from the mother liquid by centrifugation. The sugar at this stage is termed raw sugar. The remaining mother liquor is called final molasses. If the sugar is to be refined into white or table sugar it is redissolved and recrystallized in the sugar refinery. The material balance on a typical Panamanian sugar mill or ingenio is as follows:

Per 100 U. S. tons of cane ground the mill would produce:

9-10 tons raw sugar

3.3 tons final molasses

3.7 tons filter mud

18 tons bagasse (dry)

If the mill produced only raw sugar it would use about 15 tons bagasse/100 tons cane plus about 40 gallons diesel fuel or bunker fuel oil as fuel for the boilers. If the mill also operated a refinery it would burn all of the bagasse plus about 170 gallons of supplementary fuel oil per 100 tons of cane.

The milling of sugar cane, and production of raw and refined sugar, is carried out by three mills in Panama. They probably represent the largest capital investment of any agricultural processing plants in the country. Two of the mills are privately owned and a new mill has been built by the government. The Ingenio Santa Rosa of Azucarera Nacional, S.A., is about 15 miles north of Aguadulce. It is an old mill which grinds about 400,000 to 500,000 tons of cane per year. It produces refined sugar and molasses. Some of the molasses

is mixed with urea, other minerals, and vitamins and marketed at 6-7¢/lb. as an animal feed supplement called Malavit. The Ingenio operates a refinery which processes the raw sugar output of the mill. All bagasse is normally burned and all filter mud is returned to the fields. Molasses not used for Malavit is exported via the port of Aguadulce.

The other privately owned mill is the Ingenio Ofelina of Azucarera La Estrellita, S.A., between Penonome and Aguadulce on the Pan American highway. The Ingenio grinds about 500,000 to 700,000 tons of cane a year and operates a refinery which processes the total raw sugar output. There is no excess bagasse because of the refinery and filter mud is reapplied to the fields. The company operates a large (1,000 head) dairy close to the mill which supplies most of the fresh milk in Panama City. Some of the mill's molasses is used as feed at the dairy: the rest is sold domestically or exported.

The Ingenio La Victoria is a new (3-4 year-old) mill built by the government near Santiago. The ingenio currently operates at about 360,000 tons of cane per year but should be grinding its designed capacity of 530,000 tons/yr. by 1976. This is the only mill without a refinery and it does generate some excess bagasse. The 1974 season should result in about 10,000 tons dry bagasse in excess and at maximum capacity the mill will have about 15,000 tons/yr. dry excess bagasse. Filter mud is reapplied to the fields and molasses is exported.

Government plans call for two additonal mills to be built by 1977. One other 500,000 ton/yr. mill is planned for the Santiago area and a 700,000 ton/yr. mill is planned for Chiriqui province. Both new mills will produce raw sugar only and should have, respectively, 15,000 tons/yr. and 21,000 tons/yr.

Table 5

PANAMA SUGAR INDUSTRY BY-PRODUCTS

Mill and Location	Excess Bagasse	Filter Mud	Final Molasses
Santa Rosa, Agadulce	-0-[a]	18,850	16,500
Ofelina, Agadulce	-0-[a]	26,000	23,100
La Victoria, Santiago	10,000	13,500	11,800
Current Total	10,000	58,350	51,400
Estimated 1978 Total Including New Mills Planned and Increase in La Victoria	51,000	103,300	95,700

[a] Ingenio with refinery

dry excess bagasse. Table 5 shows a comprehensive accounting of current and future sugar industry by-products and wastes.

2.3 Rice Processing

Rice is a main staple crop in Panama and it is produced in varying quantities in all coastal areas of the country. The largest producing area is Chiriqui (which is the "bread basket" of the country) which produced about 50% of the total 138 x 10^3 ton/yr. Other large producing areas are Veraguas, Los Santos, Panama, and Cocle provinces. Rice is an attractive crop because of the low labor requirement once in the fields, and the long wet rainy season does not interfere with but rather aids its production. The major waste from production is the rice hull. However, the hulls have a high silica

content and have not generally been usable for animal feeds. Futhermore, except for the Chiriqui area, the wastes are not very centrally located thus making a central treatment facility impractical.

2.4 Animal Industry Wastes

2.4.1 Cattle Wastes

Almost all of the 1.3 million cattle in Panama are grass fed on open or fenced range land of widely varying quality from weaning until slaughter (in the case of beef cattle). There are, however, abatoir by-products of bones, meat scrap, and blood. Only a few of the largest abatoirs have facilities for the production of meat and bone meal but the limited quantity of this material available is of significant importance to the poultry industry. The current price of the domestic meat and bone meal near the abatoir is around $230/ton, the meal contains 52% protein. The cost of 22¢/lb. protein is the least expensive of any high protein feed supplement in Panama. Blood is usually not recovered at the abatoir.

2.4.2 Poultry Wastes

Almost 40% of the 3,706,000 chickens in Panama are raised in Panama province near Panama City. Another 18% are in Chiriqui province near David. These concentrations are caused by the availability of fishmeal at the government controlled price of $150/ton near Panama City and meat and bone meal at $230/ton near David.

Although a significant number of the birds are raised in commercial poultry houses where wastes may be collected, the number of birds in these operations is not known.

In a typical commercial broiler operation the wastes generated are manure and feathers, heads, feet, and offal from processing. For a laying flock, manure is the only significant waste. We found no indication of availability of feather meal (a meal of feathers, heads, feet, offal, etc.) in the country, nor of any refeeding, drying, or other use of manure.

2.5 Fishing Industry Wastes

The Panamanian fishing industry may be categorized into three areas: shellfish, mainly shrimp of several species and some rock lobsters: food fish, mainly tuna for export, and corvina, tuna, and other food fishes for domestic use; and anchovies and herring for fishmeal production.

There are no wastes or by-products generated in significant amounts from the harvesting and processing of food fish. This, however, seems to be an industry that could be expanded.

The shrimp fishery of Panama is a well-developed and profitable export industry. Seven species of shrimp are of commercial importance. The total catch during 1973 was 12.26 million pounds which is about the current yearly average. Two species of the seven harvested are normally machine peeled and headed at processing plants near Panama City. These two species (Titi and Cabezon) have an average combined catch of from 6 to 8 million pounds per year. Assuming that the heads and shells are 60% of the shrimp weight and that they contain 50% moisture, a total of from 1.8 to 2.4 million pounds, or from 900 to 1200 tons, of dry heads and peels would be available for some feed use. Heads and peels have been processed to yield shrimp meal in much the same way fishmeal is produced. Assuming a conversion efficiency of 5 pounds heads and shells to 1 pound meal (about the same as for fishmeal) one

could obtain from 150 to 200 tons of shrimp meal per year. This is really a small, non-commercial amount and if the selling price were even a high $400/ton the total maximum sales would be only $80,000/yr. This is certainly not enough to justify the use of existing fishmeal plants for processing the material.

In other world shrimp fisheries trash fish collected with the shrimp comprise a major part of the catch. In Panama, however, this is said not to be true, and no trash fish are returned to the docks by the fishermen.

The fishmeal industry has no significant wastes, but a discussion of the industry would, perhaps, be appropiate in this section.

There are two fishmeal producers in the Panama City area. Total fishmeal production in 1972 was about 15,000 tons with the plants running at about 30% capacity. Fisheries experts of FAO estimate that 20,000 tons may be about the limit of the resource with many years producing less than one-half that amount. The Panamanian government requires the industry to sell meal at $150 per ton to domestic buyers for domestic use. This accounted for about 40% of the 1972 production of meal. The remaining 60% was sold on the world market for over $400/ton. Major domestic users of fishmeal are the swine and poultry industries.

2.6 Citrus Processing

The main citrus industry in Panama is located in Chiriqui near Boquete. The single primary location produces 7.5×10^5 boxes of oranges at 90 lb./box in a year (total 6.75×10^7 lb./yr.). The oranges are expressed to obtain the juice and the juice is concentrated and sold as an export product. Oranges are 50% juice and 50% peels, seeds, and pulp (wet basis). The pulp and other

solid wastes are shredded and dried for sale as animal feed. Initially at 85% moisture, the material is dried to 12% moisture. At the time of our visit only 60% of the citrus pulp was being dried and sold (at $45/ton). Although all of it could be sold, the limitation was drying capacity. The total annual production of citrus pulp can be estimated to be 5.1×10^6 lb./yr. (6.75×10^7 lb./yr. x 0.5 lb. wet pulp/lb. oranges x 0.15 lb. dry pulp/lb. wet pulp), or 2.5×10^3 ton/yr. dry pulp. Since the final product is 12% moisture there is actually 2.9×10^3 ton/yr. of animal feed product. However, only 60% of this is currently available. This type of processing is a good example of what can be done with an agricultural waste produced in a central location.

2.7 Tomato Processing

In Nata there is a tomato processing facility which makes tomato concentrate products. The tomatoes are grown in the surrounding area in Veraguas. The processing consists of squeezing the whole tomatoes to separate the liquid and pulpy portions from the skins and seeds which represent the process waste. This waste is relatively small in quantity. However. it is high in protein, vitamins, and minerals.

Also at the same plant, which is run by Nestle, Libby, and Maggi. there is a milk concentration operation. Milk from local dairy farms (mostly very small) is collected and evaporated to a liquid concentrate. The wastes from the tomato operations are given to the dairy farmers in an amount proportional to the quantity of milk they bring into the plant. Thus the tomato waste is currently used in a productive manner.

2.8 Coffee Processing

A small quantity of high quality coffee is produced in the mountain areas of Chirique. The coffee is produced on small plantations and after processing sold mostly to European markets demanding this type of coffee. In countries such as Guatemala, where coffee production is larger and more central, some progress has been made in utilizing wastes for the process. However, because of the scattered low quantity of coffee waste in Panama, this is an unlikely approach.

2.9 Vegetable Handling Waste

Vegetables for sale on the local market in Panama are trucked from Chiriqui and Veraguas to Panama where there are several central storage and distribution points. These chilled warehouses are operated by Frigomida. At each location there are 2-7 tons/day (net weight) of vegetable waste due mostly to physical damage of the product and some spoilage. The wastes include bananas, plantain, papaya, potato, carrots, green peppers, yucca, and lettuce. The small quantity of waste makes this an unlikely candidate for processing. The only exception would be to make it available to the small local swine farmer.

3.0 POTENTIAL UTILIZATION OF AGRICULTURAL BY-PRODUCTS IN THE ANIMAL INDUSTRY

3.1 Current Animal Industry

The major part of animal protein in the Panamanian diet is supplied by beef. Fresh dairy products are not widely available and, although more fish is consumed in Panama than in most Central American countries, it is not usually a significant source of protein in the average diet.

The beef industry in Panama has been expanding for the last 10 years. Swine and poultry, on the other hand, have been relatively stable, the difference being feed quality and availability for the different animals--cattle can eat grass, swine and poultry cannot.

3.1.1 Cattle

The majority of the 1.3 million cattle in Panama are beef cattle. The beef industry has been expanding and beef exports are becoming significant. Panama can export slaughtered beef to the U. S., but export licenses are closely controlled by the government. Beef domestic price is also government controlled at a level which is supposed to permit wide market availability to poorer families (about 25c/lb. on the hoof in March 1974). When these prices are adhered to by the beef producer he is unable to purchase grains or other beef supplements on the world market and is constrained to grass feeding of cattle from weaning to market weight.

Grass feeding to 900-1000 pounds usually takes 4-5 years in Panama because of low-quality range and pasture, and because the 4-5 month dry season causes grass-fed cattle to lose up to 150 pounds per season. This weight must be regained in the subsequent wet season. So actually from 6 to 7 months of the year are endured with no weight gains.

When circumstances permit supplemental feeding during the dry season, cattle seem to hold their own or gain weight according to the quality of the rations. It is very apparent that a low-cost staple ration of reasonable protein and energy content would find ready acceptance by the cattlemen and would boost beef productivity greatly. No such ration is available at this time. Better breeding practices, although limited to the largest operators,

seem to be causing an improvement in productivity. The native zebu stock is cross-bred with brahman and sometimes with hereford, angus, and charolais. The improved mixed breeds have better conformation, gain faster, and respond better to feeding. More productive work could certainly be done with breeding practices with all herds in the country.

3.1.2 Swine

The swine industry in Panama is much smaller than the beef industry. In 1973 the census showed 187,500 swine and in 1972 there were 65,000 swine slaughtered. This industry is characterized by having a high demand for protein feed. As a consequence of the difficulty in obtaining such feeds, the swine population is kept fairly low. The largest number of swine are in Chiriqui (46,000), which is not surprising since it is in this area that much of the endogenous food is produced. Other swine producing areas are Veraguas (33,000), Panama (30,000) and Los Santos (33,000).

3.1.3 Poultry

Poultry, like swine, require a high protein feed; much of the protein feed materials imported into Panama are used for poultry feeding. Thus a limitation on the size of the industry is provided by availability of such feeds. Currently, most of the fish meal consumed in Panama is used for chicken feed. The 1973 census for chickens is 3,700,000, including both broiler and laying chickens. The main areas for raising chickens are Panama (1,400,000), Veraguas (534,000) and Chiriqui (660,000).

3.1.4 Sheep and Goats

The sheep and goat population of Panama is small and the existing animals are grass fed. There is, however, an increasing interest in these animals for grazing in the mountains in areas not suitable for cattle. One of the major problems to be overcome is the breeding and selection of animals optimally suited for the Panamanian climate.

3.1.5 Aquaculture

The use of aquaculture in Panama is relatively new but in demand. Its development has stemmed from AID suggested projects. Current systems are relatively small and designed for feeding of local areas. These ponds are fed via natural means. The approach might be scaled-up or accelerated by feeding the fish protein supplements such as those obtained from vegetables and fruit processing.

3.2 Current Sources of Supplemental Protein Feeds

In 1972 Panama imported about 9,000 tons of ingredients for the preparation of animal feeds. Table 6 shows that soybean meal and cottonseed meal accounted for about one-half of this amount. These imports are used

Table 6

IMPORTS OF INGREDIENTS FOR PREPARATION OF ANIMAL FEEDS: PANAMA, 1972

Material	U. S. Tons	U. S. Dollars
Total Animal Feed Ingredients	9,100	1,116,000
Soybean Meal	2,890	424,000
Cottonseed Meal	1,874	132,000
Alfalfa	570	69,000

Table 7

FEED PRICES: PANAMA, 1974*

Material	$/Ton	% Protein	¢/lb. Protein
Alfalfa Meal**	286	17	84
Cottonseed Meal**	335	41	40.8
Meat and Bone Meal**	229	52	22 (Limited amount locally produced)
Soybean Meal**	410	44	46.6
Wheat Bran**	110	16	34.3
Ricebran and Middens	120	13	46.1
Citrus Pulp	48	6	40
Urea (fertilizer grade)**	229		

*Feed prices for FOB David, Panama

**Imported products

predominantly by the swine, poultry, and dairy industries. Table 7 shows the March 1974 market prices of these and other feed supplements FOB David, Panama. The costs per pound of protein range from 22¢ to 84¢/lb. This feed cost is very high for the swine, poultry, and dairy industries and prohibitive for the beef industry. Feed prices and availability are the most important limiting factors for the entire animal industry, with protein supplements being the highest priced and least available commodity.

No significant amount of soybeans or other legumes are cultivated in the country. Some grain sorghum is being produced in Chiriqui province and shows promise of reasonably high productivity. This crop should be developed further.

3.3 Specific Uses for Agricultural By-Products

Three agricultural by-products were identified as having possible uses in the Panama animal feed industry. Also, an alternative use for another agricultural product is suggested. Waste bananas, sugar cane bagasse, and poultry manure offer possibilities of inclusion in animal rations and molasses might be more profitably used within the country rather than exported.

Several criteria were used to determine which could prove valuable in the context of Panama:

1) The waste or by-product must be of a quality such that a minimum amount of processing using a minimum of high technology can bring about a major increase in the material's digestibility or other value as an animal feed.
2) The material must be present in an amount large enough to justify the capital investment necessary to utilize it. Sufficient product must be available on a dependable basis to capture and satisfy a significant domestic market.
3) The by-product should be located in an area reasonably close to the point of final use, and the material should be currently gathered in a concentrated amount or be easily gatherable by locally existing agricultural practices.
4) The product of the waste or the use of the waste must be acceptable to local farmers and final consumers.

3.3.1 Molasses

In 1972 51,000 tons of molasses was produced in Panama which producers sold for about 1.2¢/lb. FOB their plant. In the same year Panama

imported 94 tons of pork. Faced with the same situation of low pork availability at high prices and excess molasses, the Taiwan Sugar Co. more than doubled profits on molasses by fermenting the molasses to yeast and feeding a yeast, molasses, vitamin, mineral, and roughage feed to swine. The technology is available and the Panama economic situation would seem to warrant some study o_ this possibility.

The following crude economic survey of the process is based on the normal molasses output of an average Panama sugar mill; other assumptions are stated.

Production of Pork from Molasses: Panama

Assume:
1) Pork sells for 30¢/lb. on the hoof.
2) Marketable hog weighs 200 lbs. and feed must be provided for all weight.
3) Feed efficiency: 3 lbs. feed/1 lb. gain.
4) Molasses value at mill is 1.2¢/lb.
5) Molasses contains 50% fermentable sugars by weight.
6) Yeast yield on molasses is 0.25 lb. cells/1 lb. molasses.
7) Yeast is harvested and used as a sludge or heavy cream.
8) Mill produces 15,000 tons/yr. of molasses.

Calculation of Yeast Production Costs:

Molasses value	4.8¢/lb. dry yeast
Substrate preparation	1.5
Nutrients	1.5
Fermentation	1.0
Concentration	3.0
Cost of Yeast in cream:	11.8¢/lb. dry yeast

Calculation of Feed Production Costs:

Component	% of Ration Weight	$/Ton Ration
Yeast (supplied as cream)	20	47.50
Molasses	20	4.80
Minerals, vitamins	2	5.00
Bagasse fines (fuel replacement value)	38	3.00
Moisture	20	-
Blending and Handling Feed Costs, $/Ton	-	20.00
		$80.00

Calculation of Volume:

Molasses 15,000 Ton/yr.

12,000 T/yr. fermented to 3,000 T/yr. yeast

3,000 T/yr. direct to feed

Total feed/yr. = $\frac{3,000}{.20}$ = 15,000 T/yr.

Total feed costs (15,000)(80.00) = $1,200,000

Tons pork produced = $\frac{15,000}{3}$ = 5,000

Value of pork/yr. (5,000)(0.30)(2,000) = $3,000,000

Total hogs/yr. = 50,000

Overall Economics:

Pork sales (unslaughtered hogs)		$3,000,000
less:	feed costs	1,200,000
	capital amortization and feedlot operation	200,000
Profit annually		$1,600,000

3.3.2 Banana Wastes

Bananas and plantains are produced in every tropical Central and South American country and are the major export cash crop in many of these countries. The majority of export fruit is grown on company plantations or by large, private landholdings and is cultivated with good agricultural practice. The perishable nature of the fruit has necessitated the development of rapid and efficient transportation systems from field to packing house and from packing house to dock.

In spite of the care bananas receive, almost 25% of the total crop is rejected at the packing house as unsuitable to ship. Almost all of the rejects are caused by surface blemishes which have not damaged the pulp at all. The rejects are usually then hauled to one or more central "landfills" and dumped.

A typical banana production operation in Central America may ship over 100,000 tons of fruit per year (although some operations are twice this size). Typically about 25,000 to 30,000 tons/yr. of additional fruit is produced but is unshippable and goes to secondary uses or (more commonly) to landfill.

Bananas to be exported are picked green at from thin to full three-quarters ripe. At this stage the peel is about equal in weight to the pulp. The pulp contains about 24% dry matter, most of which is starch. As the fruit ripens the pulp-to-peel ratio increases to about 3:2 (60% pulp, 40% peel) and the starch undergoes natural hydrolysis to sugars. The monosaccharides produced are mainly glucose and fructose in almost equal amounts with smaller amounts of other sugars. A material balance on 100 lbs. of fresh.

ripe banana pulp would typically give 70-75 lbs. water and 25-30 lbs. dry matter (23-27 lbs. carbohydrate, 1-1.2 lbs. crude protein, and 1-2 lbs. ash).

In many parts of Africa the alcoholic fermentation of bananas to "banana beer" is practiced, the bananas being processed by hand and the fermentation being complete in 12 hours. The liquid is drunk along with the yeast used for fermentation and seems to be of considerable nutritional significance. The ease with which this crude, anaerobic fermentation of bananas by simple yeast strains could be practical for the production of an SCP of acceptable nutritional quality for animal feed.

A process to produce a feed-grade SCP from yeast grown on bananas might be designed to fit existing local technology. In this proposed process, whole bananas would be charged to a mascerating mixer where skin and pulp (and possible stalk) is chopped and mashed. This puree would be pumped to a feed mixing tank to be diluted with water (or recycled liquid) containing necessary inorganic nutrients (generally fertilizer grade chemicals). The feed slurry would then be pumped into a fermenter, which could be a wooden vessel. After the fermenter is filled, a yeast inoculum would be added and the fermentation would be run as a batch culture. To minimize contamination the fermentation would be run at low pH (4-4.5) and growth rate and pH would be controlled by addition of anhydrous ammonia or urea on pH demand. The completed culture could then be concentrated by filtration and followed possibly by a partial drying. The yeast-fiber cake could then be either transported to a feed mill or a complete ration in pellet form could be manufactured at the fermentation plant.

Two or more batch fermentation tanks would be used to permit media preparation and product harvesting and drying to be done on a continuous

basis. A rough material balance on a plant using 25,000 tons/yr. of whole bananas shows that about eight 12,000 gallon fermentors (10' diam. 21' tall) would be necessary if they were operated in 2-day cycles. About 1800 tons/yr. of yeast would be produced (at roughly 50% protein). If a ration containing 10% protein, 20% molasses, 3% nutrient salts, and 57% fiber were formulated at 8% final moisture content, about 10,000 tons/yr. of feed ration would be produced.

This is about two and one-half times the current production of citrus pulp in Panama. Citrus pulp contains 6% protein and currently sells for $48/ton (40¢/lb. protein). Based on the same price/lb. protein, the SCP-based ration could sell for $80/ton. Total gross annual sales for the SCP ration, therefore, would be $800,000.

3.3.3 Bagasse

Although technology has been developed for both the upgrading of bagasse as a digestible fiber source and as substrate for SCP production it is not felt that either of these uses are appropriate at this time for use in Panama.

On the other hand bagasse has been used widely as an absorbent for molasses in the preparation of pelleted ruminant feeds. This may be a profitable use for excess bagasse at a mill where molasses is available and a demand for ruminant feeds exists (all mills in Panama).

3.3.4 Poultry Manure

Several years ago the government actively supported development of poultry both for meat and egg production. As a consequence there are a number of moderate size poultry operators. Poultry are fed high protein

rations and as a consequence the poultry waste is relatively high in nitrogen. Apparently, some of the manure is used for cattle feeding in Panama. but this manure does not appear to be used to its fullest. The major obstacle to the use of poultry manure for cattle feeding is education and transportation. Because of the need for nitrogen feed in Panama, there may be sufficient interest to use this supply more routinely.

4.0 PANAMA RESOURCES AND CAPABILITIES

4.1 Labor

Panama has a population of 1.5 million people, about 30% of whom live in Panama City and several hundred thousand more in the other major cities of Colon and David. The labor force is large but, like most developing countries, is unskilled and poorly educated. The standard wage for the laborer is about $3/day; while this is low by U. S. standards, it is considerably more than the $1-1.50/day in many other developing countries. As a consequence, labor in Panama is somewhat more expensive than in other developing countries. Despite this, there is still a need to develop labor intensive industries in Panama to more fully utilize the labor pool. Major problems in achieving this are: 1) transportation of the labor to areas where it is needed, 2) improving the incentives and motivation to work, and 3) identifying and educating a number of skillful personnel to fill the jobs requiring some degree of training.

4.2 Technology

The most developed technology in Panama is sugar production and fruit and vegetable processing. There is no heavy industry except for a petroleum refinery operated by Texaco. Furthermore, there is little endogenous development

of technology within the country; it all must be imported. For this reason, it would be highly desirable to promote the internal development of technology for the utilization of agricultural resources.

4.3 Material Availability

Almost all chemicals and equipment must be imported from the U. S., Europe, and Japan. As a consequence, prices for most bulk chemicals are as much as double the price in the U. S. This applies to protein feeds as well as fertilizer and other chemicals. The need to import equipment leads to greater than normal delays in construction and potentially severe problems with maintenance and supply of replacement parts. The sugar industry has adapted itself fairly well by repairing most broken parts. However, this has developed out of a need for survival and the need to process sugar in a defined time span. New industries will continue to face the problem of availability.

4.4 Transportation

4.4.1 Air

Air transportation is available in Panama, but is quite expensive. Between David and Bocas del Toro it is about $100/ton to airlift materials. Because of the expense, air transport is only used where necessary, such as into Bocas del Toro, which is inaccessible by land because of high mountains and the ocean.

4.4.2 Rail

The only rail systems in Panama are those operated in Bocas del Toro and Puerto Armuelles for the transportation of bananas. There is also a small line from David to Puerto Armuelles. However, it is apparently used mostly for people and not material transport.

4.4.3 Land

The major means of transport in Panama is by truck along a fairly good but limited highway system. The cost of trucking is only modestly expensive because of inexpensive labor. However, increased fuel prices could seriously affect the use of trucking. A major problem is the efficient use of trucks because of seasonal production of agricultural products and the coordination of loads in both directions. Maintenance and development of this industry is critical to the economy of Panama.

4.4.4 Water

Because of the long narrow shape of Panama, the Canal and its location, water transport is a mainstay of the economy in Panama. There are two major ports (Balboa and Colon) and several minor ports. Puerto Armuelles and Almirante are used for banana shipping. Aquadulce is used for all the sugar and molasses shipping, and La Palma is the main door for the Darian. Three of these ports are located on the Gulf of Panama, and as a consequence barge transport is quite feasible and the cheapest means of transport. Reinforcement of barge transport is likely to be critical to the utilization of the resources of the Darian. In addition, the maintenance of all of these ports is critical to the economy, since the two major exports of the country, banana and sugar, are exported directly from the closest ports.

5.0 CRITERIA FOR PROCESS DEVELOPMENT

The production of single-cell protein (SCP) or other upgrading of agricultural wastes in Central America faces several very important constraints.

The basically agriculturally oriented industry in these countries cannot support any of the several high technology processes already available for

SCP production. The proposal (from any sector) for initiating an SCP or other process in these countries must be closely scrutinized for the following process qualities:

1) The process should not require high volumes of expensive chemicals. All chemicals must be imported.
2) The process should not require aseptic fermentation techniques not a large capital investment in sophisticated processing equipment. Capital equipment is expensive to import and sophisticated equipment is difficult to maintain.
3) The operation should be easy and straightforward because skilled labor is almost nonexistent.
4) Transportation and logistics requirements for raw materials should be well documented, and, preferably, in existence. If possible a substrate should be chosen that is currently gathered and available at a central area.
5) The substrate must be available in an amount sufficient to justify the investment in an economically sized plant and to produce sufficient product to develop and satisfy a dependable and significant market.
6) The price of the final product must compete with other locally available feeds of the same quality with enough return on invested capital to insure economic incentive for the producer.

6.0 RECOMMENDATIONS

The following recommendations are not intended to address all the problems of tropical agriculture in a developing country, but rather they

evolve from our specific task of examining the utilization of agricultural wastes for animal feed. These specific recommendations are:

6.1 Utilization of Banana Waste

Bananas and plantains are produced in every tropical Central and South American country and are the major export cash crop in many of these countries. The majority of export fruit is grown on company plantations or by large, private landholdings and is cultivated with good agricultural practice. The perishable nature of the fruit has necessitated the development of rapid and efficient transportation systems from field to packing house and from packing house to dock: in fact, almost all railroads in Central America were built and operated by banana producers.

In spite of the care bananas receive, almost 25% of the total crop is rejected at the packing house as unsuitable to ship. Almost all of the rejects are caused by surface blemishes which have not damaged the pulp at all. The rejects are usually then hauled to one or more central "landfills" and dumped. One processor in Panama processes approximately one-half of the total rejected fruit into banana puree. However, this is done only at one of two locations and the output is currently limited by demand for the product. Banana producers are also worried that the export tax that seems imminent in some banana producing countries of Central America could reduce their sales volume on whole, fresh fruit.

A typical banana production operation in Central America may ship over 100,000 tons of fruit per year (although some operations are twice this size). Typically about 25,000 to 30,000 tons/yr. of additional fruit is produced but is unshippable and goes to secondary uses or (more commonly) to landfill.

Bananas to be exported are picked green at from thin to full three-quarters ripe. At this stage the peel is about equal in weight to the pulp. The pulp contains about 24% dry matter, most of which is starch. As the fruit ripens the pulp-to-peel ratio increases to about 3:2 (60% pulp, 40% peel) and the starch undergoes natural hydrolysis to sugars. The monosaccharides produced are mainly glucose and fructose in almost equal amounts with smaller amounts of other sugars. A material balance on 100 lbs. of fresh, ripe banana pulp would typically give 70-75 lbs. water and 25-30 lbs. dry matter (23-27 lbs. carbohydrate, 1-1.2 lbs crude protein, and 1-2 lbs. ash).

In many parts of Africa the alcoholic fermentation of bananas to "banana beer" is practiced, the bananas being processed by hand and the fermentation being complete in 12 hours. The liquid is drunk along with the yeast used for fermentation and seems to be of considerable nutritional significance. The ease with which this crude, anaerobic fermentation is carried out suggests that an aerobic, low pH fermentation of bananas by simple yeast strains could be practical for the production of an SCP of acceptable nutritional quality for animal feed.

6.2 Utilization of Poultry Manure

Although poultry manure is not available in as large an amount as banana waste, its high nitrogen content makes it a valuable material in a country where nitrogen is in short supply. For this reason it should be utilized where possible. Molasses is a good carrier and trap for the ammonia nitrogen in poultry manure and this approach should be explained.

6.3 Bagasse Pelleting with Molasses

The economic feasibility of using excess sugar cane bagasse as an absorbent or carrier for molasses and additional minerals and vitamins in a pellerized

ruminant feed should be studied.

6.4 Citrus Pulp

Currently only a portion of the available citrus pulp is dried for animal feed. This is an important resource and all of the pulp should and could be used.

6.5 Utilization of Agricultural Wastes: Process Criteria

The production of SCP in Central America faces several very important constraints. The basically agriculturally oriented industry in these countries cannot support any of the several high technology processes already available for SCP production. Thus an SCP process in these countries must be closely scrutinized for the following process qualities:

1) The process should not require high volumes of expensive chemicals. All chemicals must be imported.
2) The process should not require aseptic fermentation techniques nor a large capital investment in sophisticated processing equipment. Capital equipment is expensive to import and sophisticated equipment is difficult to maintain.
3) The operation should be easy and straightforward because skilled labor is almost nonexistent.
4) Transportation and logistics requirements for raw materials should be well documented, and, preferably, in existence. If possible a substrate should be chosen that is currently gathered and available at a central area.
5) The substrate must be available in an amount sufficient to justify the investment in an economically sized plant and to produce

sufficient product to develop and satisfy a dependable and significant market.

6) The price of the final product must compete with other locally available feeds of the same quality with enough return on invested capital to insure economic incentive for the producer.

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