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AGRICULTURAL SECTOR ASSESSMENT

LIVESTOCK SUBSECTOR

FOR HAITI

By

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Contract AID/LA-C-1261

AGRICULTURAL SECTOR ASSESSMENT

LIVESTOCK SUBSECTOR

FOR

HAITI

Report Prepared for the
U.S. Agency for International Development

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TABLE OF CONTENTS

	Page
Introduction	1
Schedule of Activities and Contacts	2
Overview	4
I. Watershed Areas	5
Role of Livestock in the Economy	5
Management Methods of Livestock	6
Environmental Interaction and Balance of Human Population, Animals and Land	8
Relative Efficiency of Labor and Land Resources as Marketed through the Present Livestock Management Systems	9
Potential of Livestock Enterprise Development	10
II. Policy Reformulation	15
National Purpose	15
Objectives of GOH Interventions	15
Areas of Intervention	17
III. Alternate Strategies of the Government of Haiti's Intervention	19
a) Determine the actual role of different types of livestock in small farm systems in the seven different watershed areas of Haiti	19
b) Improved nutrition and management with emphasis on utilization of crop residues and by-products	19
c) Genetic improvement and selection are needed to accompany improved nutrition and management	20
d) Conduct adaptive research which will identify the appropriate technology for the various types of livestock on small farms	21
e) Provide technical assistance along with suitable credit for the livestock enterprise	22
IV. Institutional Support Required to Implement the Alternative Strategies	24
Appendix 1	27
Appendix 2	32
Appendix 3	36

TABLE OF CONTENTS (cont.)

Page

Appendix 4 43

Appendix 5 48

Appendix 6 51

INTRODUCTION

The specific assignment covered in this report was to provide an assessment of the livestock and sub-component of the Haitian Agricultural Sector Assessment which was being prepared in Haiti. A draft of this report was received by USAID/ADO/Port-au-Prince, as indicated by a letter from Mr. William Garvey/ADO dated May 23, 1978, which read as follows:

> "Many thanks for sending us an advance copy of your report on the Haiti livestock sector. It arrived in time for Clarence Zuvekas to take back with him for incorporation in the overall ag sector assessment."

This final report is to fulfill the terms of the contract.

This report assesses livestock as integral parts of complex animal/crop farming systems rather than animal production as separate systems. This approach recognizes that livestock are important and that the cropping systems used greatly influence the kinds and numbers of livestock produced because of land, labor, crop residues and other available resources.

Five alternative strategies are suggested in this report for the Government of Haiti. Briefly, these are:

a) To determine the actual role of different types of livestock.
b) To improve nutrition and management by emphasizing utilization of crop residues and by-products.
c) To initiate long-range genetic improvement and selection programs.
d) To conduct adaptive research which will identify appropriate technology.
e) To provide technical assistance and supervised credit to producers of livestock on small farms.

The appendices present some background information to indicate previous studies have been conducted on the livestock situation and factors limiting its improvement. This information also helps to justify alternative strategies as outlined.

SCHEDULE OF ACTIVITIES AND CONTACTS IN HAITI: MARCH 22 TO APRIL 19, 1978

Date	Place	Contact	Activity
March 22 W	Gainesville to Port-au-Prince		Travel
March 23 Th	USAID	William Garvey, ADO	Orientation
March 24 F	USAID	Lloyd Clyburn, Dep. ADO	Orientation
March 25 Sa	Artibonite Valley	Hsung Kuang-Ton	Taiwan Rice Project
March 26 S	Bon Repos	Ahmed Zahalka	Israeli Project (small farmer)
March 27 M	Jean Rabele-north coast	William Michelle	Integrated Community Dev. Project
March 28 T	Jean Rabele-north coast	William Michelle	Northwest slope development
March 29 W	USAID	Larry Harrison, Dir/AID	Orientation
March 30 Th	DAMIEN	John Theard Livestock Inspector	Milk production
March 31 F	Croix des Bouquets		Market - every Friday approximately 800 Criollo cattle, 500 black pigs, 150 young goats
April 1 Sa	No travel		Study of pertinent information
April 2 S	No travel		Study of pertinent information
April 3 M	DAMIEN and Bon Repos	John Theard Livestock Inspector	Livestock production and feeding
April 4 T	Bos Ben area	Ahmed Zahalka	Livestock in small farm systems

SCHEDULE OF ACTIVITIES AND CONTACTS (CONTINUED)

Date	Place	Contact	Activity
April 5 W	HAMPCO	Bill Steed, Mgr.	Slaughter and meat sales
April 6 Th	Hinche	Tim Atkin, Priest	Papaye Expt. Sta. and Pignon plains
April 7 F	Hinche	Chavannes Jean-Baptiste	Integrated livestock-crop program
April 8 Sa	No travel		Report writing
April 9 S	No travel		Report writing
April 10 M	Les Cayes	Fritz Boutin, IDAI	BID cattle project
April 11 T	Les Cayes	Mike Stapleton	IDAI station at Bourdet
April 12 W	Les Cayes	Richard Watts, VPI	Levy station - DARNR
April 13 Th	Port-au-Prince	John Jacobs, Agr. attache	Report writing
April 14 F	Port-au-Prince (Pan American Day)		Report writing
April 15 Sa	No travel		Report writing
April 16 S	No travel		Report writing
April 17 M	FAMV (Fac. Agr. Vet. Med.)	Ghislain Gendron, CIDA	Review of 5-year university development program
April 18 T	HAMPCO	Bill Steed, Mgr.	Collect liver and bone samples from 16 animals
April 19 W	Port-au-Prince to Gainesville		Visited 360-sow swine operation

The Livestock Subsector Assessment for Haiti

Overview

Haiti, a country of 10,714 square miles, is a mountainous country with only 20 percent of its area below 600 feet. Topography is dominated by five mountain ranges with generally east-west axes. Rainfall varies greatly by the fact that most of the country lies in a rain shadow.

The mid-1970's population was estimated to be 4.6 million with a rural population of 3.5 million, or 77 percent. In 1971, Haiti had 616,710 farm units whose average size was 1.4 hectares (3 1/3 acres), with an average number of cultivated plots ranging from 1.8 to 3.4 per farmer. Per capita caloric intake is reported at 1,850 calories per day, or below the 2,200 calories considered as a standard. Protein intake is estimated to be 70 percent of requirements. Malnutrition constitutes perhaps the major health problem, with the prevalence of severe protein-calorie malnutrition (kwashiorkor and marasmus) in some parts of Haiti estimated to be as high as 10 to 15 percent. In addition to the protein-calorie malnutrition, vitamin A deficiency, goiter, ariboflavinosis, and nutritional anemias are also serious problems in specific regions and population subgroups. Per capita income of the rural Hatitian was estimated to be $80 in 1976.

Although cattle, goats, pigs and poultry are produced all over the country, the largest producing areas are the Northern plains, the Seguin Plateau in the south, the Central Plateau, the Cayes plain in the southwest and the Cul de Sac plain.

I. Watershed Areas

The watershed areas of Haiti in this report are similar to the legal "Departments" as outlined by GOH. These Departments include Northwest, North, Artibonite, East and South.

Northwest Slope includes the cities of Jean Rafael and Port-du-Paix; North Slope includes the cities of Cap-Haitien and Fort Liberte; the Central Plateau includes the cities of Hinche and St. Michel de l'Attalaye; the Artibonite Valley includes the major rice-growing area between St. Marc and Gonaives; the Central Basin includes Port au Prince and Croix des Bouquets; the South Slope includes the city of Jacmel and the Southwest Slope includes the cities of Les Cayes and Jeremie.

One can say that there is a great diversity of climatological, soil and elevation factors within each department or watershed area. In addition, the irrigated areas of the Central Basin for diversified crop and sugar cane production, irrigation in the Artibonite Valley for rice production and the savanna area of the Central Plateau contribute to the variation in crop and livestock systems and production patterns.

The selection of animals to match feed availability, the matching of crops to their specific low-fertility environment, the use of animals to concentrate nutrients for cycling into the limited but all-important food-crop areas, the suitability of animals and food crops for marketing over a poor transportation system, the high diversity of enterprises within the small farm systems also contribute to the diverse animal populations and animal production systems found throughout Haiti. All of this compounds the problem of an "isolated" assessment of the livestock sector in Haiti.

Roles of Livestock (by type) in the Economy: Recent census figures regarding animal numbers do not exist. Table 1 shows animal holdings per farm household according to the five geographic departments. This information is from

the 1950 general census. Table 2 is a comparison of 1950 information with the 2 percent sample survey in rural areas taken in 1970. Animal information based on a 10 percent sample survey in rural areas taken in 1971 is stored on computer cards and has not been processed. Data in Table 3 are taken from average estimates by FAO.

Given the great diversity of soil and cropping patterns within departments and the wide discrepancies among the numerical estimates, only a few brief comments are justified. Cattle and swine figures are the most significant for providing evidence of rural savings. Combining cows, heifers, calves, and bulls, the departments with the average numbers per household would be as follows: East, 1.4; South, 1.2; North, 1.07; Artibonite, 0.93; and Northwest, 0.68. Some rationale could be used for each department. The urban center of Port-au-Prince and the sugar cane-growing area in the Cul-de-Sac are major influences on cattle numbers. Swine numbers reflect the major rice-growing area of the Artibonite Valley, where rice bran is used primarily to feed pigs. The current annual availability of some 20,000 tons of wheat bran from Minoterie d'Haiti as a source of pig feed is a major stimulus to swine production near Port-au-Prince. Goat numbers per household are widely distributed, but there were two to three times more per household in the Northwest than the other four departments.

Management Methods of Livestock (by type): Animals are rarely raised as a major enterprise. Rather than a specialized livestock system geared to the efficient production of a single product like beef or milk, they have multiple objectives. The small farmer is usually trying to obtain meat, milk, young animals, storage of capital, organic fertilizer from all the same animals at virtually the same time. Not only are the objectives likely in conflict with each other, but progress toward maximization of any one of them will be slow.

Livestock production is carried out by peasant families whose holdings are small and diversified. Some calculated figures find the "average" farmer with 1.4 hectares of land in more than two parcels with 1.2 head of cattle, 2.2 goats, 2.6 pigs, 5 chickens, and 1 donkey or horse. Most 4-footed animals are tethered and fed on crop residues and by-products. Animals often represent a repository of savings second only to land. Increased crop production mediated by improved technology, multiple cropping or more crops per year is frequently accompanied by increased animal numbers.

A visit with some farmers in the Bos Ben area confirms that livestock numbers increase as crop production increases. Approximately one ton of crop residue is produced per ton of harvested crops. About 600 families who are involved in a project to increase crop yields currently own 1500 head of cattle. This is a three-fold increase from the 450 head that they owned only 2 1/2 years ago. More crop residues from increased crop yields is cited as the major factor responsible for the dramatic increase in cattle numbers.

Four animal grazing systems are practiced in Haiti: (1) free roaming (populated areas); (2) staking out (populated areas); (3) herding on open ranges (savanna and hills); and (4) fenced pasture. These systems are briefly described below:

1) Free Roaming: In this system animals are turned loose to forage in populated areas. Sometimes, a triangular wooden yoke is placed around the animal's neck to prevent it from entering enclosed private properties. These animals are not tended and they find feed wherever they can. This system limits the number of animals that a farmer can raise because of the rural code forbidding animals to roam freely. Any peasant whose field has been damaged by a stray animal has the right to slaughter it. This practice is sometimes abused and can create friction.

2) Staking Out: In this system the animals are staked out to forage in the area they can reach from the stake. This system is particularly suited to the small farmer in areas in intensive cropping where crop residues are carried to the animals.

3) Herding on Open Ranges: In this system a number of animals are turned loose on large savannahs and in the hills to graze together. They are supervised by a herder. As a rule, cattle are grazed on the savannahs and goats in the hills. The forage is generally poor.

4) Fenced Pastures: There are about 21 large ranches in Haiti where animals are grazed on a large scale in fenced pastures. There are also three farms owned by the state: Damien Ranch, FREPC and FREPLAC. The Haitian climate permits grazing the year round, but the available forage is limited by available area, rainfall, soil fertility, suitable forage varieties and application of available information.

Hogs are sometimes raised in pens with straw shelters to protect them from extreme weather. Some of these pens have cement floors, fresh water and outside runs. In most cases, however, pen-raised animals are kept in unsanitary conditions. They are frequently undernourished and diseased.

Chickens and ducks are usually allowed to run loose in yards and eat whatever they can find. Even where chickens are confined, the poor nutrition and management contribute to high mortality.

Environmental Interaction and Balance of Human Population, Animals and Land: Animals are an important and integral part of the Haitian peasant farming, transportation and financial systems. Animals are complementary to, not competitive with, the human population in that under a multiple cropping system, from 60 to 66 percent of nonmarketable nutrients from various crops can be converted by livestock to valuable animal products.

Ruminant livestock (cattle, sheep and goats) have a dual role and they are important both for utilizing natural grazing lands and for combined crop/livestock farming. These ruminants produce milk, meat and supply animal power. There are few "dairy" herds managed exclusively for milk production, but widespread milk production in conjunction with meat production is normally feasible and profitable, and is a common practice.

Pigs and poultry (non-ruminants) are widely produced throughout Haiti. For family support, these animals generally consume by-products and kitchen

wastes as scavengers of a variety of available feedstuffs that would otherwise be wasted; but for commercial enterprises, more substantial feed sources are required. Pig and poultry enterprises enjoy good markets, but feed costs often make them less profitable than enterprises based on ruminant types of livestock that subsist on forages and other cellulosic materials. Ruminant livestock enterprises are generally beneficial to crop production and provide opportunities for strengthening the farming system.

Relative Efficiency of Labor and Land Resources as Marketed through the Present Livestock Management Systems (by type of livestock): Ruminants are cattle, sheep and goats which have a digestive system that allows them to thrive on coarse, fibrous plant substances, wastes, and by-products, and sources of nonprotein nitrogen that humans cannot use for food. Utilization of these products can be greatly improved.

Pigs and poultry require the by-products from rice, wheat, corn and sorghum which contain natural protein and are lower in fiber and higher in energy than those utilized by ruminants.

Although the interest returned on the animal investment may be low, cash can readily be obtained at a nearby weekly market. Animals are an important and integral part of the peasant's farming and financial system.

There is need to more fully utilize the land and natural resources available to agriculture, including a substantial development of livestock enterprises in farming systems that are now largely devoted to the production of crops. In some regions, livestock are produced with little involvement in crop production. However, nearly all crop farmers have some livestock that contribute to family subsistence. The development of appropriate livestock enterprises on arable land offers substantial opportunity for significant improvement in total food production and in profitability of farming systems.

The improved efficiency that may be derived from including livestock enterprises in farming systems may be summarized as follows:

1) More effective use of natural resources - climate, land and soil, and vegetation.

   a) Use of rainfall-deficient areas not suited to cropping.
   b) Use of associated non-arable lands and soils in humid regions.
   c) Use of lands remote from markets.
   d) Use of forages grown in crop rotations.

2) Conversion through feeding to livestock of crop residues and by-products to produce foodstuffs for human consumption.

3) Contributions to incomes and food supplies.

   a) Production of milk and milk products.
   b) Production and sale of meat animals.
   c) Providing animal power for crop farming.

4) Production of animal manures for application to land for improvement of soil productivity.

5) Contribution to soil conservation and sustained land productivity by use of forages grown in rotations to control erosion to control weeds and pests and to improve soil fertility, with animal enterprises providing the income from consumption of these forages.

6) Contribution of livestock enterprises through stabilization of seasonal and yearly food production, improvements of net farm income, better distribution of labor and power-requirements for production, thus supporting more profitable farming systems.

Potential of Livestock Enterprise Development (by type of livestock):

Basic animal science technology is available in various places in the tropics and subtropics for greatly increasing the output from livestock enterprises in Haiti. However, this basic information needs to be adapted to conditions which exist in Haiti, and applied to a wide variety of integrated crops and livestock production systems. The proper inclusion of livestock enterprises into various farming systems has the potential of improving the profitability of the farming systems.

Some of the potential advantages of livestock enterprise development are as follows:

1) Providing nitrogen in the crop rotation. Livestock enterprises permit the exploitation of forage legumes in the cropping systems and greatly reduce the need for nitrogen fertilizers. There is good field evidence that a well-adapted perennial forage legume will contribute 100 to 200 pounds of nitrogen per acre to the soil for each year of growth; and this soil nitrogen will be released by normal decay of legume roots and nodules over a period of 2-3 subsequent years of crop production.

2) Soil improvement for greater production. The inclusion of a mixed planting of perennial forage grasses and legumes for a period of 2 or more years, followed by several years of cropping, is one of the most effective ways of controlling soil erosion on crop lands and of improving soil structure and permeability to rainfall. This is due to the mass of fibrous roots that the forage grasses produce, plus the deeper penetration of the forage legume root system. This mass of roots that the forage species produce in the soil gradually decomposes in the years following plowing of the forage plantings to contribute nitrogen to the subsequent crop, and to the addition of semi-permanent soil humus that makes the soil more mellow and productive.

3) Providing feed for livestock. The growth of perennial forage plants on each field for 2 or more years followed by a few years of cropping is an integral part of a farming system that includes livestock enterprises. Such forage can be managed to produce highly nutritious feed for ruminant livestock in the form of pasture, or feed cut and fed green, or grass silage, or hay. Their use is fully compatible with benefits in soil improvement. The storage of forages for feeding livestock during dry seasons is a badly needed practice in Haiti for milk production and for the support of satisfactory reproduction and growth of meat animals.

4) Animal manures for enhancing soil productivity. The inclusion of ruminant livestock enterprises in mixed farming systems permits the collection

of animal manures and spreading these on the land for incorporation in soil during land preparation for crop production. Manures are widely recognized as being strongly beneficial to crops when incorporated in the soil, but the supply is very small unless livestock enterprises are included in a substantial way in farming systems. In addition to supplying major nutrient elements (nitrogen, phosphate, potash, calcium and magnesium) manures are quite useful in providing "trace" elements in an available form. These trace elements are essential for crop growth, and one or more of these are often deficient in crop lands. They are: iron, zinc, manganese, copper, boron and molybdenum.

The benefits of manure applications to the soil extend through 2 or more seasons of cropping. The effective use of manure involves little or no purchased inputs, and the labor involved in obtaining benefits may be spread over periods when crop production has low labor requirements.

5) Improved control of plant pests. The inclusion of forage plantings in the farming system has important values not found in systems without livestock enterprises. There is a reduction in the abundance of insect pests, nematodes, plant diseases and of weeds that attack crops when there is a regular sequence of perennial forages for 2 or more years in a 5 to 6 year rotation.

These pests are naturally decimated during the periods when forages are grown on the fields because of the absence of susceptible host plants.

6) Effective use of non-arable lands associated with cropped lands. Combined farm systems are not limited solely to crop lands. Farmers using systems that include ruminant livestock enterprises may make effective use of associated or nearby lands that are non-arable (rough topography, stony, or shallow soil, lands subject to flooding, etc.). Haiti has 2.7 million hectares of land of which 66 percent is non-arable and 1.4 million hectares

is considered to have over 40 percent slope. These lands may be improved for forage production by prudent management and thus enlarge the size of the farm. Whether grazed or harvested as forage, these lands should provide additional feed, which is the real basis for livestock enterprises. Roadsides, field borders, wet areas and areas that have been allowed to grow up to brush may all be significant sources of feed.

7) Profitiable use of crop residues and by-products. Livestock provide an excellent means of utilizing crop residues and by-products to add to total farm production. Vines, stalks and leaves, straw, chaff from winnowing grain, and other plant residues may be used for livestock feed. These plant products after being fed may ultimately be returned to the soil as manure. In such form they are more useful in maintaining soil fertility than when incorporated into the soil directly. The additional values come from the livestock to which they are fed. In addition to crop residues on the farm, locally available by-products from central processing plants (cotton gin waste, rice milling, wheat milling, sugar cane processing) are important feedstuffs. Many of the products are now wasted, under-utilized or exported.

8) Animal products for human foods. There is a widespread shortage of protein foods in Haiti, and this situation could be greatly improved by the inclusion of more efficient livestock enterprises in farming systems. Meat, milk and eggs are often preferred protein foods for man since they are not only palatable, but also rich in the types of essential amino acids that are chronically deficient in plant proteins. Ruminant livestock (cattle, sheep and goats) are particularly beneficial since these animals convert forages and roughages into meat and milk. Ruminants produce these highly prized nutritious foods from plant materials that are otherwise useless to man as foodstuffs.

Milk production and sales that are continuous through the year provide a cash flow to farmers that is critically needed to cover on-going farm expenditures in seasons when there are no crop/annual sales. Since meat animals (male animals and less productive females) are a separate source of income to milk production, these sales constitute still further diversification in income as well as increasing total amount. Furthermore, the labor requirements for livestock enterprises are well-distributed throughout the year and thus largely avoid adding to peak labor problems related to crop production.

II. Policy Reformulation

The Government of Haiti should consider certain policy reformulations which impact upon the livestock subsector. The Government needs to formulate a national livestock policy. The United States during its early assistance to Haiti, IDAI and more recently UNDP/FAO have approached the improvement of meat and milk production through the establishment of a number of government operated or controlled experiment stations or breeding stations. Given the limited numbers of trained personnel and the limited financial resources available, a national livestock policy is greatly needed. Appendix One includes a brief outline of 10 proposed projects as suggested by the International Coordinated Program for Milk (PICDL) and the International Program for the Development of Meat (PIDV), both of which were prepared by the FAO mission between February 13 and March 4, 1978.

Past experience and the current situation would indicate there are some serious limitations to government operated and/or controlled livestock experiment stations and breeding stations. Well-conceived livestock programs of the past have had limited impact on breed changes, nutrition and management practices, vaccination and disease control and increased meat and milk production. A critical review of past programs should indicate approaches that should be modified or avoided.

National Purpose: The national purpose of the livestock subsector can be outlined as follows:

1) To improve the quality of life of the agriculturalist and family;
2) To provide a more nutritionally balanced human diet by increased protein production from livestock and energy production from crops;
3) To utilize the natural resources more effectively for increasing livestock production; and
4) To stimulate the interaction between livestock and crop production on small farms.

Objectives of GOH Interventions: The three major areas of GOH interventions should be focused on: 1) Technology; 2) Training; and 3) Infrastructure.

Adapted technology - The basic technology is available in developed countries for maximum livestock production. However, this technology needs to be adapted to conditions which exist in Haiti. Livestock production in Haiti is essentially all on small farms. Consequently, multidisciplinary teams, including livestock specialists, need to focus on methodology necessary for conducting and integrating livestock and farm crops systems research. Both off-station and on-station research needs to be conducted to verify recommended livestock production and management practices. Many sophisticated practices requiring expensive and high technology inputs can be recommended immediately. However, many have negative cost-benefit ratios and are therefore uneconomical.

Appropriate training - Many Haitians have received either short-term practical training or long-term academic training. For a variety of reasons, many of these trained people have been lost to the agricultural and livestock systems. Conditions need to be changed to stop the negative flow of technicians from the systems and then to provide both short-term practical and academic training to those who can contribute to the development of livestock and crop systems.

Improved infrastructure - The infrastructure for animal agriculture, livestock production and marketing in Haiti is poorly developed. Secondary roads into livestock zones are inadequate or non-existent. Some potentially more important livestock-producing areas such as the Central Plateau and the Seguin Plateau are practically inaccessible. Water constitutes a serious constraint to increased livestock production. Watering points are particularly scarce in both the hills and the savannas and a substantial improvement in water supply is needed to support a livestock program. Availability of only limited credit is a definite impediment to improved livestock production.

Greatly expanded credit tied to sound technical supervision is highly recommended. Of course, technical assistance is greatly needed to make the total livestock-crop system function.

Areas of intervention: Many behavorial characteristics and sociological factors need to be carefully considered. In general, many small farmers can be considered as good animal caretakers. They are mildly responsive to the economic situation, but overall they are rated as conservative, and suggested changes must be low risk. They are skeptical of outsiders and extremely conventional. They appear to sell their livestock largely at their convenience and when they need money. Some biases expressed by producers are: (a) breeding services that are free cannot be of value; (b) black or dark-skinned pigs are greatly preferred over white pigs. These two examples are only to illustrate that many biases do exist among livestock producers, and that these should be given due consideration.

Furthermore, a number of livestock programs have been tried in Haiti in the past with varying degrees of success. These programs should be reviewed in depth. It is necessary to know the reasons why these programs failed or why they were successful prior to implementing more programs. Only three past programs will be cited.

First - What has been the impact of the IDAI cattle and swine breeding programs in the Les Cayes area? Excellent cattle and swine were imported for breeding purposes. However, after a number of years the impact as evidenced by changes in cattle and swine breeds has been much less than was originally planned or desired. It would appear that it is impossible for GOH or any government to set up a sufficient number of breeding stations to have a very great impact on breed changes within a relatively large area. Conclusion: Associations, cooperatives and individuals must be given the responsibility of breed improvement with the technical assistance of the government. Basically

the same rationale can be followed for the Brahman cattle program at the Papaye Experiment Station in the Hinche area.

The Hampco swine breeding program in the Cul-de-Sac area hasn't been in progress long enough to be able to be critically evaluated.

Areas of intervention can be grouped as follows:

1) Determine the actual role of different types of livestock in small farm systems in the seven different watershed areas of Haiti.
2) Improved nutrition and management with emphasis on utilization of crop residues and by-products.
3) Genetic improvement and selection is needed to accompany improved nutrition and management.
4) Conduct adaptive research which will identify appropriate technology for the various types of livestock on small farms.
5) Provide technical assistance along with suitable credit for the livestock enterprise.

III. Alternate Strategies of the Government of Haiti's Intervention

a) Determine the actual role of different types of livestock in small farm systems in the seven different watershed areas of Haiti.

Personnel including U.S., GOH and expatriates need to become more acutely aware of the importance of animals in the Haitian peasant's food chain, farming, transportation and financial systems. People with substantial financial resources who give great credence to dogs, cats, birds, horses and non-economically contributing animals in their own lives often appear to be prejudiced against the economical contribution of animals in the poor peasant's real world.

1) Find out what the actual economical role of livestock is in some of the representative farming systems and watershed areas of Haiti. How economically important are animals, and how do they actually contribute as: a) storage of capital; b) a market for inedible crop residues and by-products; c) a market for some family labor; d) improvement to family diet; e) association with social prestige; f) percent of cash farm income; g) forms of traction; h) movers of goods, cartage and packing; i) hides and skins; and j) producers of animal wastes, fertilizer, fuel, methane gas and recycled nutrients.

Most of the above points can be quantified but no study or report was found in which these factors were included. These could be included as part of other surveys and studies.

b) Improved nutrition and management with emphasis on utilization of crop residues and by-products.

Maize stover, sorghum stover, rice straw, sugarcane tops, bean stover, sweet potato vines and other types of crop residues are being extensively used for the feeding of livestock. Most of these products

contain between 35 and 50% TDN (Total digestible nutrients). A TDN of 42 to 45% is needed to satisfy maintenance requirements, and if it is less than 40%, animals usually lose weight. The solution is to improve digestibility and energy levels of diets composed primarily of these materials without greatly increasing the cost.

This can best be done in the following ways:

1) Greater use of high energy products such as molasses and mixtures of molasses and urea for both energy and protein. Possible increased production of cassava as an intercrop.

2) Introduction and testing of tropical legumes which could be grown in small quantities that could be fed as a protein and energy supplement with the crop residues.

3) Introduction and testing of a variety of tropical grasses. Only a very few varieties of tropical grasses have been introduced into Haiti during the past 20 years.

4) Verification is needed concerning the value of mineral supplements. Mineral deficiencies appear to be widespread and limiting livestock production. However, protein and energy may be more deficient. Based on research in other countries, mineral supplementation of grazing ruminants during the rainy season has the highest cost-benefit ratio of any nutritional practice that can be used. This situation may not be true with the tethered ruminants in Haiti if protein and energy are greatly limiting.

c) Genetic improvement and selection are needed to accompany improved nutrition and management.

Over the centuries livestock in Haiti have adapted to their environment by lowered levels of production, small weight gains or loss of weight, smaller skeletal growth, lowered fertility with fewer calves being produced, reduced milk yields and shorter lactation periods. Experience and research programs in many tropical areas have

indicated the need to develop good breeding, selection and management programs for maximum exploitation of improved nutrition and management. It doesn't appear that artificial insemination in the near future is a viable alternative to the use of breeding animals because of the technical competence of the people, communications and distribution of animals. Females of the indigenous breeds should serve as the bases for genetic improvement.

1) Young Holstein, Jersey and Brahman bulls should be imported in relatively large numbers. However, this will depend on the development of a system for distribution and use.

2) Young boars should be obtained and distributed so that they can be used to upgrade the current black native breed. Sufficient numbers of boars could be purchased from HAMPCO to operate this program.

3) Male goats of both improved milk and meat breeds, and hair sheep, should be imported. Again, the numbers to import will largely depend on the development of a system for distribution and use.

NOTE: Improvement of the genetic capability of livestock through crossbreeding and selection is a long-term program. Because it is a long-term program, it should be started using the best crossbreeding systems which are indicated for Haitian conditions. It is anticipated that the development of a system for distribution and use of breeding stock would be a part of the "Integrated Community Development Programs" or other similar programs.

d) Conduct adaptive research which will identify the appropriate technology for the various types of livestock on small farms.

Attempts to transfer the technology usually recommended for enhancing the output of meat, milk or eggs have met with very limited success on small crop/livestock farms. This is mainly because the single-

commodity emphasis by the technicians was incompatible with the priorities of the farmer. The usual order of priorities for keeping animals on small farms are: 1) reduction of risks from cropping; 2) accumulation of capital; 3) render services, e.g., traction, fertilizer; 4) satisfy cultural needs; 5) ensure status of prestige; 6) provide food; and 7) generate income. In general, attention is not given to obtaining a high rate of output of food products because other goods and services have higher priority in the small-farm system.

Thus research is needed to identify the appropriate technology which is compatible with the priorities of the farmer and that which is economical.

e) Provide technical assistance along with suitable credit for the livestock enterprise.

The application of appropriate production, management and health care practices and techniques are essential to the success of animal programs. Many more trained technicians need to be provided who can instruct producers on the use of appropriate technology which will help to improve livestock production. Likewise, many more veterinarians and veterinarian paramedics are needed to help identify and control the diseases and parasites which are common to the different types of livestock found in Haiti.

This cadre of trained technicians needs to work in the rural zones with the small farmers who own the livestock. They also need to work in conjunction with those who are providing suitable credit for animal enterprises.

The small farmers who wish to develop livestock enterprises as part of the farming system require a different type of credit from that

suitable for seasonable cropping. Livestock enterprises require the purchase of animals that will not be fully productive until they reach maturity and either begin production of milk or until meat animals can be marketed. Consequently, it is necessary to have longer term loans for livestock purchases and for other needs in support of the livestock enterprise.

The Government may directly, or through farmer cooperatives, provide such credit to small farmers on terms that are suitable to effective development of new or expanded animal enterprises. An integral part of such credit may be the continuing counsel and guidance to the borrower on how best to use the credit for economic improvement. Without suitable credit and counsel, the advantages of combined crop/livestock farming systems may not be exploited successfully by the small farmers.

IV. Institutional Support Required to Implement the Alternative Strategies

The alternative strategies outlined in Section III are:

a) Determine the actual role of different types of livestock in small farm systems in the seven different watershed areas of Haiti.

b) Improved nutrition and management with emphasis on utilization of crop residues and by-products.

c) Genetic improvement and selection are needed to accompany improved nutrition and management.

d) Conduct adaptive research which will identify the appropriate technology for the various types of livestock on small farms.

e) Provide technical assistance along with suitable credit for the livestock enterprise.

These five alternative strategies focus on livestock as an integral part of small farm animal-crop production systems rather than animals as separate enterprises. Consequently, the major objective is to help improve animal production within these various complex animal-crop production systems. Small farm systems are highly variable, complex and require rather high levels of managerial skill to operate effectively. There is a need for the development and application of technology which is applicable to small farm systems.

Institutional support envisions the following suggested positions:

1. Production Economist, Livestock - Responsible for the development of alternative "a", which is to determine the actual economical role of livestock in some of the representative farming systems and watershed areas of Haiti. This person would need to be familiar with livestock production systems and the use of the methodology required to obtain the necessary information.

2. Livestock Production Specialist - This person would be responsible for the development of different livestock production systems. This acknow-

ledges that there are many important livestock production systems currently being used because of the different types of livestock and varied cropping systems. Information is available to improve these production systems. This person would be responsible for incorporating presently available information into the various livestock production systems. Specific attention would be given to improving breeding programs, improved nutrition by utilization of crop residues and agricultural by-products, production of supplemental pastures and legumes as well as emphasis on other appropriate technologies. This person would be responsible for transmitting recommended procedures to the "delivery systems".

3. Animal Nutrition Research Specialist - This person would have the responsibility for conducting adaptive research on "key" components which are important constraints in the livestock production systems. These constraints would need to be determined by those familiar with animal-crop production systems. It is possible to do research on only components of a system rather than the total. An analysis of some important livestock production systems in the different watershed areas of Haiti would identify numerous constraints which require adaptive research. A few of these possible areas are briefly mentioned under alternative strategy "b". However, many others may be equally important.

4. Agricultural Finance and Credit Specialist - This person would have the responsibility of developing guidelines for livestock loans which are applicable to small farm systems. Responsibilities would also include guidelines for the analysis of the technical feasibility of proposed livestock programs. Credit is greatly limiting the expansion of both livestock and crop production. Both credit and technical assistance in the form of supervised credit is needed to assist with the expansion of livestock and crop production in small farm

systems. The primary function of this position would be to develop and assist with the implementation of a supervised credit system as outlined in item "e".

5. Short-term technical consultants - It is fully recognized that additional technical support would be needed in a number of technical areas, and that this support could be effectively utilized after the program as outlined is in progress.

Appendix 1.

Programme International de Coordination
du Developpement du Lait (PICDL)
et
Programme International Pour Le
Developpement de la Viande (PIDV)

Prepared by PICDL - PIDV/Haiti FAO mission
between February 13 and March 4, 1978.

Proposed Projects

Project 1. Pilot center for development of hides and skins and the utilization of animal by-products.

a) Establish a pilot center to promote the production and commercialization of quality hides and skins and the utilization of by-products from animals which are slaughtered.

b) Assist with formation of necessary personnel for the center.

Type of project: Technical assistance, training of personnel and furnishing of necessary equipment.

Proposed cost: $490,000

Project 2. Establishment of Rural Tannery Institute.

a) Establish a rural tannery institute to standardize methods in the country for appropriate tanning and the production of quality skins. Training of necessary personnel.

b) Establish and initiate a program for the formation of primary products and their utilization and the equipment for preparation and treatment of hides and skins.

c) Assist the authorities in quality control of these products and their commercialization on the basis of quality.

Type of project: Technical assistance and furnishing necessary equipment.

Proposed cost: $308,000

Project 3. Establish a Center for Training Milkers at the St. Vincent Foundation (RRPP Salésiens, Cap Haitien).

a) To train annually 12 herdsmen in the proper techniques of hand milking.

Type of project: Technical assistance and the provision for cattle and equipment.

Proposed cost: $52,240

Project 4. Analytical Laboratory for Feedstuffs.

a) Establish a laboratory for the analysis of feedstuffs and forages for the purpose of:

1) to acquire better information on the chemical and nutritional composition of locally available feedstuffs;

2) to serve as a quality control laboratory for feedstuffs

imported or produced locally;

3) to aid in the interpretation of experimental results obtained with rations prepared in the pilot feed plant.

Type of project: Technical assistance and equipment for laboratory at Faculty of Agronomy.

Proposed cost: $50,000

Project 5. Pilot program for utilization of local feedstuffs for animal feeding.

1. Applied research to demonstrate the use of agricultural and agroindustrial by-products in animal feeding.

Type of project: Technical assistance, weighing and mixing equipment.

Proposed cost: $45,500, GOH to furnish 20 to 30 dairy cows, 20 sows and their pigs.

Project 6. Develop a Center for the Production of Mules.

1. Production and distribution of mules in the Central Plateau.

Type of project: Provide donkeys.

Proposed cost: $42,000

Project 7. Assistance with Dairy Plant at Damien.

To remodel the receiving and dairy manufacturing plant at Damien to handle 3,000 liters per day which would serve as a pilot and demonstration plant in the training of technicians in dairy manufacturing. The dairy would also produce reconstituted milk from powdered milk and support milk production in the Cul-de-Sac plains which is being collected for the plant.

Type of project: Technical assistance, training of dairy technologists and providing complementary dairy equipment.

Total cost: $90,000

Project 8. Assistance to IDAI/SEN, the Institut du Developpement Agricole e Industriel/Societé d´ Equpement National.

To assist IDAI/SEN in the evaluation of the credit demand in the dairy area including milk production, dairy plant remodeling and dairy manufacturing.

Type of project: Technical Assistance.

Total cost: $30,000

Project 9. Creation of a Milk Board (Bureau of Milk).

Creation of an organization in the Livestock Service at DARNDR and a Milk Board for the programing and coordination of various activities in dairy development in Haiti.

Type of project: Technical assistance of a specialist in

the planning and development of dairy industry.

Total cost: $54,000

Project 10. Development of Animal Production.

To develop animal production under a coherent and established national plan. This is to satisfy the internal demand, increase the value of the by-products and increase the revenue to the producer.

Type of project: GOH desires to obtain from FENU $1,004,000 to equip the Papaye Station near Hinche in the Central Plateau which would serve as a focal point to increase animal production of meat and milk in this region. Technical assistance during four years and equipment (if PNUD expresses a desire and intention to finance this project). Experts in animal production and economics totaling 168 man months. Consultants totaling 16 man months, scholarships supplies and equipment.

Total cost:	Out of country costs	1,006,000
	National contribution	1,500,000
	TOTAL	$2,506,000

Appendix 2.

Rainfall and Soil Information on the Central Plateau

The Central Plateau with some 100,000 ha of natural grassland has been the object of several studies. Parts of this land have been suggested for crop production, sugar cane production and cattle production. The fact that this land is presently not well utilized would indicate that there are some definite limitations regarding rainfall distribution, soil drainage and soil fertility.

Information in Table 1 indicates that the average annual rainfall is about 1138 mm, or 45.5 inches. Months of major rainfall are during the six months from May-October. This area has a six-month rainy season during high temperatures followed by a six-month dry season.

Information is provided in Tables 2 and 3 with regard to soil pH and the availability of major soil nutrients, CaO, MgO, P_2O_5 and K_2O. Information in Table 2 resulted from the analysis of 12 soil samples collected in the area of St. Michel de l'Atalaye, while that in Table 3 was obtained from soil samples collected in the area of Hinche and the Papaye experiment station.

In general, the samples present a wide range of values. Soil pH is relatively high for tropical soils, and averaged 6.2 for those values in Table 2, while all the values in Table 3 except two are above 7.0. Soil is relatively well-supplied with calcium and magnesium. Phosphorus values are very low to low, and there is no information on available nitrogen, but it can be expected to be very low. The soil potassium is somewhat low.

Soils would need to be improved with applications of nitrogen, phosphorus and potassium for greatly improved plant growth, for either forage or food crop production.

Table 1. Annual Rainfall and Average Precipitation per Month in mm during Ten Seasons at St. Michel de l'Atalaye

Month	Precipitation mm
January	10.9
February	6.5
March	34.2
April	73.3
May	171.4
June	189.4
July	119.1
August	163.7
September	143.6
October	118.5
November	75.3
December	32.3
TOTAL:	1138.2

Source: Geology by Wooding, Brown and Burbank, 1924

Table 2. Analyses of Soil Samples Collected in the St. Michel de l'Atalaye Area, Central Plateau (analyzed in 1975)

Sample Number	Soil pH	In pounds per acre			
		CaO	MgO	P_2O_5	K_2O
21	7.1	53,780	2,470	14	430
22	6.0	10,130	1,773	1	91
23	6.1	4,603	845	Trace	42
24	6.8	25,460	2,734	Trace	199
25	5.9	4,416	812	Trace	42
26	5.6	2,609	812	1	61
27	7.7	75,600	513	7	137
28	5.8	2,133	812	2	48
28A	6.4	1,840	4,800	1	68
29	6.0	6,970	1,044	Trace	123
29A	5.5	2,074	878	1	48
33	5.5	2,985	1,110	2	75
MEAN	6.2	16,050	1,550	2.5	114

Source: Analytical Soil Laboratory, University of Florida, Gainesville, FL

Table 3. Soil Analysis: Soils of Haiti, Central Plateau (analyzed in 1972)

Sample Number	Soil pH	In pounds per acre			
		CaO	MgO	P_2O_5	K_2O
30167	6.0	3,914	763	3	36
30168	5.8	6,648	1,277	2	118
30169	7.8	44,928	9,490	1	340
30170	8.0	69,394	5,694	8	417
30171	8.4	16,386	1,036	1	83
30172	7.9	7,494	1,525	2	118
30173	7.7	17,910	4,578	3	271
30174	7.7	17,124	1,592	2	153
30175	8.0	6,648	2,056	1	97
30176	7.2	10,074	729	1	139
30177	7.4	25,518	2,255	5	452
30178	7.1	9,486	3,630	1	153
MEAN	7.4	19,627	2,885	2.5	198

Mineralogical Analysis

Sample Number	Lab #	Sand	Silt	Clay	Texture	Clay Minerals Present
30168	1	39	25	36	clay loam	Predominantly montmorillonite, some kaolinite, very little quartz
30178	2	19	14	67	clay	Predominantly montmorillonite, some kaolinite, very little quartz

Source: Analytical Soil Laboratory, University of Florida, Gainesville, Florida

Appendix 3.

Development of Beef Cattle Production in Haiti

Synopsis of a Report by G.O. Mott
Professor of Agronomy, University of Florida
(Result of a five-day visit, January 24-29, 1972)

Objective: To study the feasibility of expanding beef cattle production in Haiti utilizing the natural grasslands of the Central Plateau for cow-calf operations.

In Haiti there is an estimated 100,000 ha of natural grassland in the Central Plateau which is not being utilized and which has potential for a cow-calf, beef cattle operation. This area may have potential for crop production under proper management, in which case its use for crop production may be of greater benefit to the people of Haiti.

There is also a surplus of by-product feeds available in the country: molasses from the sugar mills, wheat bran from the flour mill, cottonseed meal and limited quantities of soybean and copra meals from the oil mills. These are feeds which can be effectively utilized at some phase of the beef cattle production scheme.

Justification for beef cattle production

As the income level of the Haitian people is increased, and with the development of a middle income class, the local demand for beef will increase. It is estimated that at least 25% more beef could be sold locally if available. Hampco also indicated that their export of beef in the Caribbean could be expanded several-fold if the animals were available for slaughter in Haiti.

The beef cattle herd in Haiti

The Creole cattle, which are probably descendants of the early Spanish and French cattle, provide the foundation for a breeding program to improve the herd in Haiti. These cattle attain a maximum weight of about 300 kilograms, and the dressing percentage is frequently as low as 42%. The animals at slaughter are usually 4 to 6 years of age, which means that large quantities of feed resources are consumed just to maintain these animals to this advanced age. Work in the South American Tropics indicates that reducing the killing age of the slaughter animals from six to two years of age in the beef herds would save enough feed to double the number of breeding cows. The cost of maintaining slaughter animals an additional four years is very high in terms of feed resources. A beef cattle feeding scheme designed for Haiti should provide for a killing age of about 24 months and certainly not in excess of 30 months.

Improving the quality of cattle and increasing production potential

There are two aspects of improvement in the beef herds which need attention and development. The quality of the animals needs improvement with respect to dressing percentage and cut-out percentage of lean meat. The dressing percentage can be increased from about 42% to over 55%, and the ratio of lean meat to bone can be increased substantially by introducing Zebu (*Bos indicus*) and European breeds (*Bos taurus*) into a cross-breeding program using the Creole as the foundation of the herds. If such a cross-breeding program were initiated, the production potential would also be greatly increased so that the production of a 390 kilogram slaughter animal could easily be attained at 24 months of age. (Example: Assuming a 25 kilogram calf at birth and a slaughter weight of 390 kilograms, which is equal to a liveweight gain of 365 kilograms, an average daily gain of .5 kg during a two-year period would be required.)

The feed supply

There are two principle sources of feed for the beef cattle herds in Haiti for which other classes of livestock do not offer any serious competition. The pastures are only effectively utilized by the ruminant animal, and the excess of by-product feeds from the sugar, flour and oil mills offer supplemental feeds for use during stress periods in brood cow herds and for the finishing of slaughter animals.

1. The natural savannas

A very superficial examination of the natural savanna in the central plateau suggests that the species available are relatively low in nutritive value, especially during the dry season. Species in related genera in the South American and Australian savannas provide an adequate ration for the brood cow for only three to five months early in the wet season. During the remainder of the year, these grasses can be expected to provide little more than a maintenance ration. If no other feed is supplied during stress periods to the brood cow, two very serious situations usually result. At weaning time the dam has lost much of her body reserves and the calf may be permanently stunted, a condition from which it never recovers. The dam is at such a low level of nutrition, the estrous cycle is delayed so that many cows produce a calf only every other year, resulting in a calf crop of less than fifty percent.

Some of the possible alternatives which are suggested by the soils and climatic conditions of the central plateau are as follows:

a. Replace the native grasses with improved grass species on the more favorable sites to provide high quality feed either as pasture or hay for the stress periods.

b. Grow annual cultivated feed crops such as sorghum, corn or cassava on favorable sites to provide supplemental feed as part of the total feed program.

c. Grow perennial soilage crops such as Napiergrass, Merckergrass or Guatemalagrass as supplemental forages.

2. The finishing forages

Calves should be weaned at 6 to 8 months of age and should be moved close to the source of supplemental feed, the place of slaughter, the centers of population, and the export facilities for the most efficient type of operation. Improved and intensively managed pastures should be the primary source of feed in the finishing phase. Supplemental feeds should be used to supply additional energy and protein to make up for the deficiency of pasture as a sole source of feed. Nearly 10 times as much weight will have to be transported if supplemental feed is moved to the Central Plateau where the calves are produced than will be required if the calves are moved close to the feed supply. Also, if the calves are left in the Central Plateau for the finishing phase, they will be consuming pasture which could be otherwise used for additional brood cows.

If the finishing phase were to be carried out in the Cul-de-Sac plain, the Northern plain or the Leogane plain, improved pastures would have to be established and the necessary facilities developed for feeding supplemental feeds on pasture. A feed mill for processing and mixing feeds would have to be built to provide the rations for the finishing phase.

The recommendations with respect to the species of grasses to use in the finishing pastures and their management will require further study. Cultivars of the Digitaria and Cynodon genera would probably be best adapted and most productive for an intensive management system. It should be pointed out that if supplemental feeds such as wheat by-products and the oil meals are fed on pasture, a large quantity of plant nutrients (N, P and K) will be generated and returned to the pasture in the form of urine and manure. After a year or two of feeding, the pastures will be highly productive from the fertilizer value of the supplemental feeds.

3. Supplemental feeds

It is understood that large quantities of molasses are available. Molasses provides an excellent source of energy for finishing beef cattle on pasture. The oil meals from cotton seed, soybeans and coconuts are excellent protein sources for finishing cattle and can be fed along with molasses. In addition, wheat by-products and rice bran are available. An analysis of the costs of these products will have to be made to determine the least cost rations for use in the pasture feeding scheme.

Some estimates of the potential size of the enterprise

For purposes of the following analysis, it is assumed that there are about 100,000 hectares of savanna in the Central Plateau, and most of the feeder cattle will be generated in this area. It is further assumed that about 20% of the savanna is suitable for development into improved pasture, leaving a ratio of 4 ha of native pasture to 1 ha of improved pasture. If these estimates are reasonable, then the potential carrying capacity of the Central Plateau is about 40,000 cows.

Assuming a 70% calf crop under good management, there should be 28,000 calves each year at full capacity. If breeding females are replaced at the rate of 20% per year, 8000 replacement heifers will enter the total herd each year, and 8000 cull females will leave the herd. This should maintain the breeding females at approximately 40,000 head, plus the one and two year heifers, plus the necessary bulls.

It should be understood that these are very rough estimates and may be in error by a factor of 20%. If the males go to the finishing pastures along with the females not saved for breeding, then 20,000 weanling calves will be available for the finishing pastures. In addition, about 8000 cull cows will be available for slaughter each year, making a total of 28,000 head. Assuming

260 working days/year (52 weeks x 5 days), this number of animals would mean an average daily kill of 108 animals.

Other considerations

1. The above analysis is based only upon the development of a cow-calf operation in the Central Plateau and does not take into consideration the development of a beef operation among the small farmers of the country. Supplying small farmers with improved breeding stock and advising them on their feeding systems is a scheme that should be exploited. It is not known how many slaughter animals this type of enterprise will generate.

2. It must be emphasized that the development of a cow-calf ranch operation in the Central Plateau will require a large amount of investment capital. This investment will be in breeding stock, fences, machinery for establishment of improved pastures and buildings. Along with the investment capital must come a high level of expertise. A ranch manager with many years of experience in an operation as large as that envisioned for the Central Plateau will in a large measure determine its success or failure.

Conclusions

1. The production of beef on a scale as indicated in this report is technically feasible in Haiti.

2. The development of the beef cattle feeding systems outlined will require a large capital investment by the government or incentives which will encourage private capital to make the necessary investment.

3. A more optimistic estimate would suggest that at least five years would be required to show any profit from the enterprise or tangible benefit to the country.

4. The recommendations made are predicated on the willingness of the government to provide the necessary regulatory control over the export of by-product feeds so that adequate supplemental feeds will be made available for the beef cow herds and for the finishing operation.

5. If the government plans to undertake the development without outside private capital, then an adequate number of specialists should be trained to provide the expertise necessary to manage all phases of the operation.

6. The successful development of a beef cattle enterprise is contingent upon the government supporting the development of an infrastructure including roads for transporting livestock and feedstuffs, feedmill for processing feeds, and marketing facilities.

Appendix 4

Results of Analyses of Liver and Rib Bone Samples

December 22, 1978

Mr. Bill Steed
Vice President & General Manager
HAMPCO
P.O. Box 1105
Port-au-Prince, Haiti

Dear Bill:

Enclosed is a summary of the 16 liver samples which we collected from HAMPCO with your excellent cooperation. As you recall, we were interested in trying to get an overview of what some of the mineral problems could be. We realized these animals weren't growing too fast. Consequently, their mineral requirements are not as high as more rapidly growing animals. Low energy and protein levels have a tendency to mask some of the potential mineral deficiencies. We also assume that the parasite load has a direct effect on some of the minerals in the liver. However, allowing for these various influences, I'll make the following comments.

1. Phosphorus is probably the most limiting mineral deficiency. We have some bone samples that we are analyzing which should verify this.
2. Cobalt, manganese, and zinc do not appear to be limiting in the animals under present conditions.
3. The iron levels in the livers are relatively low, which reflects more the parasite load in the animals rather than a dietary deficiency. This interpretation is based on comparative liver samples from other cattle which indicate healthy low parasitized animals usually have liver iron levels approximately twice the level of these cattle.
4. Copper levels below 50 µg/gram are considered very deficient. Copper appears to be the most deficient trace element.

I would like to call your attention to sample numbers 8-231 and 9-290 compared to 11-407 and 13-349. These four animals were reported to have come from the Cayes area, yet the first two copper levels are very low compared to the latter two. There is sufficient variation among samples from the same area to suspect that some of the animals may have access to supplemental copper and zinc. This may be in the form of a brass ring in the nose which supplies some copper and zinc, or galvanized metal troughs or roofs, etc.

Although we had only one sample from the Island of Gonave, it was certainly low in copper.

5. This brief information adds justification for some fundamental improved nutrition, sanitation and management practices including mineral supplementation, parasite control, etc.

I hope these data will be of some interest and value to you and we hope to get the bone data to you soon.

With best wishes for a successful New Year, I remain,

Sincerely,

Joseph H. Conrad
Professor and Coordinator
Tropical Animal Science Programs

rf

Enclosure

xc: Dr. L.R. McDowell
Dr. J.K. Loosli
Mr. Lloyd Clyburn

ANALYSES OF LIVER SAMPLES - PORT AU PRINCE, HAITI
(Samples collected at HAMPCO - April 18, 1978)

December 1978
Florida AID Mineral Project

J. H. Conrad
Analysis by N. Wilkenson

Sample No.	Sex	Age	Cobalt Co	Copper Cu	Iron Fe	Manganese Mn	Zinc Zn	Location	Comments
			----------μg/g----------						
8-231	F	6	0.28	57	186	10.1	179	Cayes	
9-290	M	5	0.31	76	198	9.4	276	Cayes	
10-181	M	7	0.22	33	154	12.1	305	Island of Gonave	
11-407	M	4	0.36	220	133	9.0	262	Cayes	
13-349	F	5	0.32	256	147	12.8	236	Cayes	
14-332	F	6	0.35	162	172	8.3	500	Central Plateau	Thin (one calf)
15-328	M	5	0.38	97	175	10.3	654	Central Plateau	
16-424	F	7	0.26	196	149	9.8	282	Cayes	
17-348	F	6	0.29	145	182	10.1	140	Artibonite Valley	(one calf)
18-330	F	7	0.26	156	196	13.5	244	Central Plateau	
19-354	F	8	0.32	321	161	9.4	347	Léogâne	
20-444	F	7	0.41	68	297	8.5	256	Cayes	
21-367	F	8	0.27	108	206	13.2	625	Artibonite	Very thin, liver flukes
22-335	M	5	0.20	124	127	10.6	384	Central Plateau	Liver flukes
23-323	F	5	0.35	261	164	9.2	332	Central Plateau	
24-360	F	6	0.27	37	247	6.2	130	Artibonite	
Normal level			.08-.12	200	180-340	>8.0	84-130		

February 1, 1979

Mr. Bill Sneed
Vice President & General Manager
HAMPCO
P.O. Box 1105
Port-au-Prince, Haiti

Dear Bill:

Enclosed is a summary of the calcium, phosphorus and magnesium analyses of the eight rib bone samples we collected from HAMPCO with your excellent cooperation.

I have listed the normal levels for the calcium, phosphorus and magnesium as a percent of ash. This information substantiates the hypothesis that phosphorus is probably the most limiting mineral deficiency. The normal level is considered to be 18%, but levels below 16% are considered to be deficient.

Perhaps one of the surprises is the low level of calcium in the bone ash. These are also lower than we usually find even in deficient animals.

It appears that mineral supplements would certainly be beneficial, but as we know this can be said for a number of other nutrients along with energy and protein.

Again, we hope that these data are of some interest and value to you.

With best wishes, I remain,

Sincerely,

Joseph H. Conrad
Professor and Coordinator
Tropical Animal Science Programs

rf

Enclosure

xc: Dr. L.R. McDowell
Dr. J.K. Loosli
Dr. Lloyd Clyburn

ANALYSES OF RIB BONE SAMPLES - PORT AU PRINCE, HAITI

(Samples collected at HAMPCO - April 18, 1978)

Sample No.	% Ash	Calcium		Phosphorus		Magnesium	
		%	% of Ash	%	% of Ash	%	% of Ash
1	64.86	22.89	35.29	9.71	14.97	0.52	0.80
2	67.08	22.38	33.36	9.44	14.07	0.30	0.45
3	64.00	22.45	35.08	9.68	15.12	0.34	0.53
4	64.39	20.35	31.60	9.61	14.92	0.36	0.56
5	63.64	20.60	32.37	8.68	13.64	0.30	0.47
6	63.18	20.09	31.80	8.68	13.74	0.26	0.41
7	64.64	19.56	30.26	9.07	14.03	0.33	0.51
8	65.97	20.29	30.76	8.66	13.13	0.28	0.42
Totals	51,776	16,861	26,052	7,353	11,362	269	415
Means	64.72	21.07	32.57	9.19	14.20	0.34	0.52
Normal levels	65%		38%		18%		0.70

Bone samples were collected from the middle of the third rib but animal number and location from where they originated were unknown.

January 1979
Florida AID Mineral Project

J. H. Conrad
Analyses by N. Wilkenson

Appendix 5

UTILIZATION OF RESIDUES OF SWEET POTATO *(Ipomoea batatas, L.)* IN CATTLE FEEDING

Introduction

In tropical areas, crop residues are important food resources that can be used to complement or substitute pasture in periods of scarcity. In the specific case of sweet potato, two types of residues are presented:

a. The rejected root, pertaining to those roots that for their form, size or physical damage during harvest, have no commercial value.

b. The foliage, leaves and stems that are frequently left in the field.

The roots are characterized by their high energy content (starch) and good carotene content, although they are low in protein (3%). The foliage is a material equivalent to good quality pasture (12% crude protein and 65% digestibility), which is very well accepted by livestock.

Based on these antecedents, a study was done in CATIE with the purpose of evaluating the use of the aerial part of the plant and the roots of the sweet potato for feeding young bulls for beef.

Relevant Results

Table 1 presents weight gains obtained with different treatments under study, which consisted of different combinations of sweet potato roots and foliage and minimum amounts of urea.

In Table 1, it can be observed that the highest weight gain was achieved with the combination of 50 percent roots and 50 percent foliage; nevertheless, with foliage used alone or with small proportions of root (25%), gains close to 700 g/day were obtained. This can only be achieved with forage of very good quality.

The economic analysis of this study showed that in spite of good biological results, sweet potato production strictly for feeding animals is not profitable as it would enter into competition with production for human nutrition. On the other hand, if one considers sweet potato production for human consumption, and the use of residues for feeding animals, the rentability figures change notably.

Table 2 presents the economic analysis which is based on one hectare planted in sweet potato. Roots of commercial value (88%) were sold for human consumption, while leftover roots (12%) and foliage were utilized for feeding young bulls. It is interesting to note that the crop residues from one hectare of sweet potato are enough to feed 5.5 young bulls weighing 200 kg for a 100-day period, with a weight gain of 710 g/day. The maintenance of this complementary activity allows an additional profit of 48 percent.

Projections

Based on the potential shown by sweet potato in this study and in studies made by the Cropping Systems Project of CATIE, the research group in the Center's Animal Production Program is presently conducting two experiments in the management of this crop.

In the first experiment, a study is made of the effect of leaf pruning on production of total biomass (roots and foliage) in two sweet potato varieties (short season and long season). The basic idea in this work is to study to what extent the management of sweet potato as a forage plant can affect root production, in order to find a way of raising the crop to get more foliage production without it having a significant effect on the amount and quality of the root.

The study in the second experiment is on the conservation of sweet potato foliage for silage, with the addition of different proportions of residue roots and urea. The purpose of this study is to develop a methodology for conserving the sweet potato residue so it can be used in animal feeding, since it is a highly perishable product and its availability normally coincides with periods of forage abundance.

This article was written by Ing. Danilo Pezo and Dr. Héctor Muñoz, Specialist in the Animal Production Program and Deputy Director of CATIE for Research, respectively. It is based on the thesis of Ing. J. Backer in 1976 as a requirement for the *Magister Scientiae* degree.

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Table 1. Weight gain (g/animal/day) in young bulls fed different combinations of sweet potato roots and foliage.* (Backer, 1976).

Ration (% dry base)		Consumption Kg DM**/100 kg LW***	Weight Gain g/animal/day
Roots	Foliage		
0	100	2.4	656
25	75	2.3	708
50	50	2.3	847
75	25	2.4	805
100	0	2.4	823

* The rations were given equal protein content (11% of raw protein) by the addition of urea

** DM = Dry Matter

*** LW = Live Weight

Table 2. System of agricultural production and meat production based on the cultivation of sweet potato

Agricultural Production		Meat Production	
Area considered:	1 ha	Foliage yield, MT:	13.0
Sweet potato variety:	C-15	Rejected root yield, MT:	1.8
Crop cycle, days:	150	Protein supplement in form of urea, minerals and consumption, kg dry matter /animal/day	4.9
Sale of 88 percent of roots produced; MT:	13.2	Number of animals to feed:	5.5
Sale price, US$/kg of root:	0.13	Days of feeding:	100
Total costs of crop production:	US$660	Weight gain, g/day:	710
Profit, percentage:	152	Total cost/animal/day, US$:	0.28
		Price/kg live weight, US$:	0.58
		Profit, percentage:	48

BACKER, J. Integral Use of Sweet Potato (*Ipomoea batatas, (L) Lam)* in Meat Production. Thesis, *Magister Scientiae*, Turrialba, Costa Rica, UCR/CATIE, 1979. 72 p. (Thesis in Spanish).

Appendix 6

Seminar on
Utilization of Local Ingredients in Animal Feeds
Non-Ruminant Nutrition - Pigs
Jamaica, April 14-18, 1975

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A dynamic or stable swine industry is based on the local availability of an economical supply of energy feeds. Feed represents 70-80% of the cost of producing pork, but at least 75% of the feed cost is the cost of energy feeds. Therefore, the geographic areas which have energy feeds available in large quantities at reasonable prices have the best potential for economical swine production. Examples of these are Denmark with barley, north-central United States with corn, and southeast Asia with rice by-products.

Men and pigs are both considered to be non-ruminants. As such, they both have similar digestive systems and nutritional requirements. Many demographers and planners are saying that the pig competes directly with man for available food supplies and that pork production will decrease as population pressures increase. In theory, this is basically true; however, in practice, we find the pig converting large quantities of inedible, undesirable and fibrous by-products, with low nutritional value for humans, into highly nutritious and delectable meat. The pig is by far the most efficient among farm animals in conversion of feed energy to body energy and ranks only behind the chicken and fish in efficiency of conversion of feed energy to body protein.

Geographic areas which have energy feeds available in large quantities at reasonable prices will have a definite advantage in swine production. Increased swine production in the tropics is dependent on increased production of feedstuffs and maximum utilization of locally produced feedstuffs. Several research groups have been concentrating on various aspects of both these problems. The challenge to the swine producer is maximum utilization of locally produced and locally available feedstuffs. Much progress has been made on this topic recently and many research results have been published. The best single reference is a recent book by W.G. Pond and J.H. Maner entitled *Swine Production in Temperate and Tropical Environments*.

A few pertinent statements will help to focus on the topics of utilization of feedstuffs available in the tropics.

1. There is no single nutritionally balanced feedstuff. Every feedstuff has nutritional limitations, and these deficiencies must be corrected for most efficient gains. For example, Opaque-2 corn supplies a good nutritional balance of amino acids and energy for pigs over 50 kg liveweight, but it is extremely deficient in minerals. The more that is known about the nutrient composition of a feedstuff, the easier it is to correct these deficiencies.

2. Many feedstuffs contain toxic materials which greatly limit their use. Some processing or special treatment is necessary to detoxify or reduce the level of toxicity. Properly heat-treated soybean meal contains an excellent balance of the essential amino acids. However, raw or poorly processed soybean meal contains digesting enzyme inhibitors (trypsin) and the availability of some of the amino acids is greatly reduced. Other examples are gossypol in cottonseed meal and hydrogen cyanide in cassava. More information is needed on the toxic principles which limit utilization of feedstuffs produced in the tropics.

3. A mixture of two or more energy sources often produces better results than single sources alone. Frequently, the ingredients are deficient in different nutrients, so they tend to complement each other.

4. The nutritional value of a single feed ingredient varies widely and is dependent on many factors. In general, high levels of fiber reduce the energy level which is especially true of cereal by-product feeds. Increasing the bone level in meat by-products reduces the protein level, and higher than normal silica levels in fish meal, rice by-products, and mineral mixtures indicate contamination. Feedstuffs must be traded on the basis of a guaranteed content and analysis.

5. The nutrient requirements of swine vary greatly during the life cycle. Low energy and fibrous feeds which have little value for young pigs may be highly recommended for sows during gestation. Forage and green chopped material has little energy value for young pigs, but can be used as a major source of energy for sows during gestation.

These points also indicate that, in formulating nutritionally balanced swine diets, it is necessary to know the nutrient requirements of swine, the

nutrient composition of the feedstuffs, the level of toxic materials which may limit their use and maximum levels of feedstuffs for optimum performance.

Nutrient Requirements of Swine

Tables 1 and 2 give the nutrient requirements of swine as recommended by the United States National Research Council Committee on Nutrient Requirements of Swine. These levels are based on the experimental evidence available and the best judgment of the committee in summarizing all the experimental work. Therefore, these figures are close to the actual nutrient requirements of the pig, and they are recommended for use as guides in formulating rations and feeding swine. A more detailed explanation can be found in "Nutrient Requirements for Swine" which can be obtained by writing to: National Academy of Sciences, Printing and Publishing Office, 2101 Constitution Avenue, Washington, D.C. 20418, and enclosing $2.50.

Supplying these levels of nutrients to healthy pigs with the inherited ability to grow should result in optimum performance and feed conversion. The recommended levels do not contain a margin of safety. In some cases, it may be desirable to increase the level of nutrients whenever storage conditions may cause some deterioration or when higher levels might be desirable for other reasons.

If nutrients are supplied at levels below those recommended in the tables, adverse changes in performance and feed conversion can be expected. A number of frequently occurring nutritional deficiencies are found in practice. Among these are water, energy or dry matter, protein or amino acids, calcium, phosphorus, iron, zinc, and multiple vitamin deficiencies.

Nutrient Composition of Feedstuffs and Some of Their Limitations in Swine Diets

Tables 3 and 4 give the nutrient composition of some feedstuffs commonly used in swine feeds. Only a limited number of feedstuffs have been listed for comparative purposes. More detailed information can be found in the Latin American Tables of Feed Composition published by the University of Florida and in other references cited at the end of this paper. These tables show that the nutrient composition of energy, protein, and vitamin feeds varies widely. Ripe bananas contain approximately 870 kcal of digestible energy per kilogram compared to corn which contains about 3,300. Similar contrasts can be pointed

out between the nutrient composition of all feedstuffs. The swine producer is urged to learn more about the nutrient composition of feedstuffs, variations in composition that can be expected, and how these feedstuffs can be combined for most efficient and economical production.

Protein supplement for use with tropical feedstuffs. Protein requirements for growing-finishing pigs vary between 18 and 13%, depending on age and weight. Sorghum contains approximately 9% protein, molasses contains 3% protein, cassava contain 1 to 2% protein, and bananas about 1% protein. Most all energy feedstuffs available in the tropics contain low levels of poor quality protein. Additional protein is always required and can best be supplied from a nutritionally balanced protein-supplement.

In Table 5 are listed five protein supplements. The first four have been formulated with protein feeds which are frequently available in the tropics. Formula 5 is listed for comparative purposes and indicates how soybean meal could be used if available. In formulating these protein supplements, consideration was given to research results, level of nutrients, availability of ingredients and nutritional deficiencies of tropical feedstuffs. Formulas 1 and 3 contain cottonseed meal which often contains gossypol. Nutritional value of these could be improved by the addition of up to 2.5 grams of iron per kilogram of protein supplement.

These protein supplements are formulated to furnish adequate levels of protein, minerals, trace minerals, vitamins, and antibiotics when used with locally available energy feedstuffs. Thus, a properly formulated protein supplement should supply all the nutrients needed to correct the nutritional deficiencies of the energy feeds.

A 30% protein supplement is recommended when an additional source of energy is required. In addition, a 30% protein supplement can easily be made by mixing the following ingredients:

70 parts of a 40% protein supplement and
30 parts of a 10% protein energy feed

or

60 parts of a 40% protein supplement and
40 parts of a 15% protein energy feed.

The 10% protein energy feed could be sorghum and the 15% protein energy feed could be rice or wheat by-products.

A sorghum-protein supplement feeding program for growing-finishing swine is outlined in Table 7. This could be called a conventional feeding program. With this program, all ingredients are dry; they are ground and mixed together and fed in a self-feeder or trough. This program is based on complete mixed rations, but is not suitable for use with feeds containing high levels of moisture such as molasses, fresh cassava or bananas. Experience has shown that swine production can be greatly increased if feeding programs are designed specifically for maximum utilization of locally available feedstuffs. Recent research has shown that excellent and economical results can be obtained by feeding large quantities of molasses, cassava, and bananas when these products are economically available.

A molasses feeding program for growing-finishing swine. A series of feeding trials have been conducted at the University of Florida to study maximum utilization of molasses for growing-finishing swine. Details of these studies were reported by Combs and Wallace (1969, 1970, and 1972). Results show that 20% molasses can be successfully fed to pigs between 5 and 50 kg liveweight and 40% molasses can be fed to pigs over 50 kg. Levels of up to 60% molasses were fed, but gains were 8% slower than with 40% molasses. Therefore, research has indicated that a molasses feeding program as outlined in Table 8 can be used successfully for growing and finishing swine.

Approximate daily feed intakes are also listed in Table 8. There is no need to mix these ingredients together in a mechanical mixer. The liveweight of the pigs and the feed intake can be estimated. Twice daily, the ingredients can be spread in a trough by hand. For example, the required amount of protein supplement can be placed in the trough first, then the ground sorghum grain, and then the molasses. These ingredients can then be mixed slightly using a hoe or other suitable tool. Swine feeding programs must be adapted to locally available feedstuffs and to local conditions. Other ingredients can easily be substituted for the sorghum or corn in these rations.

A cassava feeding program for growing-finishing swine: Research conducted at C.I.A.T. in Colombia has clearly shown the value and potential of using cassava as a major source of energy for swine. Fresh cassava contains about 65% water, 35% dry matter, and about 1 to 2% protein. Yields are often low, between 3 and 20 tons per hectare, but, experimentally, 78 tons per hectare have been produced. About 4.0 kg daily of fresh chopped cassava supple-

mented with 0.75 kg of a 40% protein supplement has resulted in daily gains of 0.75 kg for growing-finishing swine.

In Table 9 is a suggested cassava feeding program for growing-finishing swine. Cassava can be fed as fresh chopped cassava or sun-dried cassava. Formulas and estimated daily intakes in Table 6 are based on research results. Where molasses is available, 5 to 10% is recommended to reduce dustiness and increase the palatability of diets containing high levels of cassava. When molasses is more economical than cassava, 20 to 30% molasses is recommended as outlined in Table 8.

Some varieties of fresh cassava contain toxic levels of hydrogen cyanide (HCN). It is recommended that high yielding varieties with non-toxic levels of HCN be produced. However, cooking in water, drying in the sun, or oven drying at 80°C have all been shown to reduce the level of HCN present.

Banana feeding program for growing-finishing swine is outlined in Table 10. The one percent level of protein and the 80% level of moisture in bananas requires that they be supplemented with both a high level of protein and additional energy. Based on recent studies conducted by I.N.I.A.P. in Ecuador, mature bananas with skins and a 30% protein supplement have produced excellent results with growing-finishing swine.

It is possible to obtain good results by free choice feeding of the mature bananas with skins and the 30% protein supplement. However, protein supplement intake can best be controlled by hand feeding the required amount twice daily and then providing all the mature bananas with skins the pigs will consume. The 30% protein supplement is recommended to supply additional energy and dry matter. It can be made from the 40% protein supplement as indicated in the discussion related to Table 3.

Rice by-products are available in many tropical areas and are widely used in swine diets. Rice is the most important food crop in many tropical areas. At times, the price of rice makes it competitive as a feed for swine, but, wherever rice is grown, its by-products are used extensively in swine diets.

Rough rice or paddy contains the hull which is high in fiber and poorly digested. Rough rice can be substituted for some or all of the corn in swine diets. It has been shown to have about 75 to 80% of the feeding value of corn.

Brown rice has a chemical composition and energy value similar to that of corn. The feeding value is equal to that of corn, and it can be substituted for part or all of the corn in a swine diet when the price is equal or less than that of corn.

Rice bran is usually a mixture of bran, polishings, and some hulls. Rice hulls have no nutritive value for swine, but are sometimes added as an adulterant. Rice bran often contains about 12% fat which easily becomes rancid when stored under the conditions of a tropical environment. A number of studies show that good quality rice bran can be used to replace 20 to 30% of the corn in growing-finishing swine diets. Results will vary with the quality of rice bran. Rice bran at levels up to 30% of the diet has approximately the same feeding value as corn. But when rice bran replaces half of the corn, its feeding value decreases to 80 to 90% of that of corn. Recent studies at the University of Florida (Campabadal, 1974) compared levels from 20 to 45% rice bran for growing-finishing swine. Higher levels of rice bran (35 to 45%) decreased daily gain, feed intake, and feed efficiency. Gastro-intestinal irritation was observed to increase as the percent of rice bran in the diet increased. The exact reason for the irritation is not currently known.

Wheat flour by-products are classified on the basis of fiber content as follows: bran more than 9.5%, middlings or mill run between 4 and 7%, red dog between 1.5 and 4%. A majority of these by-products are used in animal diets and, usually, the higher the fiber, the lower the price. Comprehensive information on the milling process, chemical composition, and nutritional value of wheat by-products for swine can be found in a recent publication by the Miller's National Federation. Wheat flour by-products contain many essential nutrients, but are considered primarily as sources of energy.

Wheat middlings and by-products with lower levels of fiber are usually considered as energy substitutes for corn. Wheat bran has often been included in farrowing rations, but its use in growing-finishing diets is limited because of the fiber content. Studies were conducted by Neufville and co-workers at the University of Florida to determine the effects of different levels of wheat bran on performance and carcass quality. A 27% level of wheat bran resulted in gain and feed efficiency comparable to a corn-soybean meal diet, but 39% wheat bran significantly affects gains. Although gains were depressed and more feed per unit of gain was required, the calories of digestible energy

per unit of gain were essentially the same with 0, 8, 20, 27, and 39% wheat bran.

Sweet potatoes contain about 30% dry matter, 1% protein, and are considered a relatively good source of energy. Sweet potatoes can be fed raw, but cooking increases consumption, protein digestibility, and rate of gain. Cooked sweet potatoes have been shown to have about 80% of the value of corn when compared on a dry matter basis. Dehydrated sweet potatoes on a dry matter basis could be expected to have about 5% higher value and raw sweet potatoes about 5% lower value than cooked sweet potatoes.

Protein feeds. Protein feeds should be selected primarily on the basis of cost per unit of quality protein, but consideration must also be given to the fiber, phosphorus and vitamin content.

Soybean meal. Properly heat treated, solvent, extracted soybean meal containing 44 to 49% protein is an excellent source of protein for all ages of swine. For young, growing swine, its balance of amino acids is excelled only by dried skim milk. Soybean meal has become the standard with which to compare other sources of protein.

Cottonseed meal. This is one of the most widely produced sources of protein and is often the least expensive. The high level of free gossypol and the low level of lysine have restricted the use of cottonseed meal in swine diets. Gossypol is found in the pigment glands of cottonseed and the level in the meal varies with the oil extraction process used. Prepress solvent extracted cottonseed meal contains relatively high protein quality and is usually low in free gossypol. Both expeller process and direct solvent process result in much higher levels of free gossypol.

Recent research has shown that cottonseed meal containing less than 0.04% free gossypol may safely serve as the only source of supplemental protein for swine. A level of 0.01% of free gossypol in the total diet has been suggested as a safe level. Research has shown that the addition of ferrous sulfate to the diet will bind the free gossypol so it will not be absorbed by the pig. If the level of free gossypol is higher than 0.01% in the total diet, iron should be added as ferrous sulfate in a 1:1 weight ratio up to a maximum of 500 mg/kg of added iron in the total ration. The addition of 1% of calcium hydroxide in the presence of recommended levels of iron also helps in the inactivation of gossypol.

The low lysine content of cottonseed meal can be improved by mixing with protein sources containing higher levels of lysine such as fish meal, blood meal or soybean meal. The addition of synthetic lysine should also be considered.

Peanut meal. Peanut meal contains a high level of protein, but the balance of amino acids limits its use. A swine ration based on corn and peanut meal is very deficient in lysine and is low in methionine and tryptophan. These amino acid deficiencies can be corrected by mixing the peanut meal with higher lysine supplements such as fish meal, blood meal, and soybean meal.

Peanut meal processed from peanuts heavily infected with the fungus *Aspergillus flavus* contains high levels of aflotoxin which have been shown to produce toxicity in swine. Production of aflotoxin can be controlled by rapid drying of the harvested peanuts to 8% moisture or below.

Coconut meal. Although coconut meal contains only about 20% protein, it is an important source of protein in many tropical areas. Nearly maximum performance can be expected with levels up to 20% in the diet. However, a 40% level of coconut meal has been shown to greatly reduce gains and cause a 30% increase in feed required per unit of gain.

Other sources of plant proteins. A number of varieties of peas and beans are being used to supply a part of the protein requirements for swine. Many of these sources contain between 20 and 30% protein. Some have fairly good amino acid balance, but are often deficient in methionine and cystine. It is expected that these will become more important in the future.

Protein feeds of animal and marine origin. The nutrient composition of these protein sources sometimes varies greatly. Quality of meat and bone meal and tankage tends to vary because the products are made from different proportions of carcass trimmings, inedible meat, and condemned carcasses. Methods of processing, including time, temperature, humidity, and the presence of contaminants, all influence nutritive value. Generally, animal proteins are of excellent quality, but their feeding value is usually improved when fed in combination with a good source of plant protein. Rations of corn and animal or marine proteins are usually low in tryptophan and may contain an excess of calcium. Animal and marine proteins often have a greater potential for rancidity and salmonella contamination than plant proteins.

Tankage and meat and bone meal produce good results when they are used to supply one half of the supplemental protein. Blood meal contains about 80% protein, but, because of its lower digestibility and taste, it should be used to supply not more than 25% of the supplemental protein.

Anchovy fish meal is one of the world's most important fish meals with the center of production located in Peru. In general, good quality fish meal is superior to meat and bone meal as a source of supplemental protein. Good quality fish meal can be satisfactorily fed as the only source of supplemental protein for swine of all ages and weights. Therefore, the relative price of fish meal protein as compared to other sources of protein will help determine the level of fish meal protein in swine diets.

Feather meal. Hydrolyzed feather meal can satisfactorily be used at the 5% level in growing-finishing swine rations. However, it should not be used as the only source of supplemental protein.

Poultry by-product meal. This by-product of poultry processing plants containing about 55% protein has been satisfactorily used at the Florida Station as the only source of supplemental protein in growing-finishing swine rations.

Shrimp meal contains over 45% protein of relatively good quality, but, because of its high mineral content, it should be used in combination with plant proteins.

Summary

A major factor limiting swine production in the tropics is the availability of energy and protein feeds. Research has clearly demonstrated that it is possible to use much higher levels of molasses, bananas, cassava, and cottonseed meal in swine diets than in the past. Correcting the nutritional deficiencies, proper processing, and removing or neutralizing the toxic materials present are necessary for maximum utilization of tropical feedstuffs. Energy feeds should be selected on the basis of cost per 1,000 kcal of digestible energy, but consideration must also be given to the levels of dry matter, protein, and fiber. Protein feeds should be selected primarily on the basis of cost per unit of quality protein, but consideration must also be given to the fiber, phosphorus and vitamin content.

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Table 1 NUTRIENT REQUIREMENTS FOR SWINE (PER KILOGRAM OF RATION)[a]

Nutrient	Starting, growing and finishing weight, kg. 5-10	10-20	20-35	35-60	60-100	Gestation	Lactation
Daily gain, kg.	0.3	0.5	0.6	0.75	0.9		
Digestible energy, kcal.	3,500	3,500	3,300	3,300	3,300	3,300	3,300
Crude protein, %[b]	20-22	18	16	14	13	14	15
Lysine, %[b]	1.0	0.8	0.7	0.6	0.55	0.5	0.5
Minerals:							
Calcium, %	0.8	0.65	0.65	0.50	0.5	0.75	0.75
Phosphorus, %	0.6	0.5	0.5	0.4	0.4	0.5	0.5
Salt, %	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Iodine, mg.	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Iron, mg.	80	80	80	80	80	80	80
Copper, mg.	6	6	6	6	6	6	6
Manganese, mg.	20	20	20	20	20	20	20
Selenium, mg.	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Zinc, mg.	50	50	50	50	50	50	50
Vitamins:							
B-Carotene, mg.[c]	4.4	3.5	2.6	2.6	2.6	8.2	6.6
Vitamin A, I.U.[c]	2,200	1,750	1,300	1,300	1,300	4,100	3,300
Vitamin D, I.U.	220	200	200	125	125	275	220
Vitamin E, mg.	11	11	11	11	11	11	11
Riboflavin, mg.	3	3	2.6	2.2	2.2	4.0	3.5
Niacin, mg.	22	18	14	10	10	22	18
Pantothenic acid, mg.	13	11	11	11	11	16	13
Vitamin B_{12}, mcg.	22	15	11	11	11	14	11

a. These requirements are based on U.S. National Research Council recommendations in which high energy diets were fed to swine for optimum performance. Energy and protein levels were derived primarily from corn-soybean meal type diets. Performance and feed conversion will normally be reduced with lower energy diets.

b. Approximate protein levels required to meet the essential amino acid needs. Lysine is one of the amino acids most limiting in swine rations. If cereal grains other than corn are used, extra 1 or 2 percentage units of protein may be required.

c. Carotene and vitamin A values are based on 1 mg. of B carotene equalling 500 I.U. of biologically active vitamin A. Vitamin A requirements can be met by carotene or vitamin A or both.

Table 2 NUTRIENT REQUIREMENTS FOR SWINE--AMOUNTS PER ANIMAL PER DAY[a]

Nutrient	Unit.	Starting, Growing and Finishing Weight, kg. 5-10	10-20	20-35	35-60	60-100	Gestation	Lactatic
Feed intake (air-dry)	kg.	0.6	1.2	1.7	2.5	3.5	2	5
Digestible energy	kcal.	2,100	4,400	5,600	8,250	11,550	6,600	17,000
Crude protein	gm.	130	225	270	350	450	280	800
Minerals:								
Calcium	gm.	4.8	8	10	12.5	17.5	15	38
Phosphorus	gm.	3.6	6.3	8.5	10	14	10	26
Salt	gm.	3	6	8.5	12.5	17	10	25
Iodine	mg.	.01	.02	.03	.05	.07	.04	.1
Iron	mg.	48	96	136	200	280	145	400
Copper	mg.	3.6	7.2	10	15	21	11	30
Manganese	mg.	12	24	34	50	70	36	100
Zinc	mg.	30	60	85	125	175	90	250
Vitamins:								
Vitamin A	I.U.	1,300	2,200	2,200	3,250	4,550	7,900	16,500
Vitamin D	I.U.	130	250	340	315	440	500	1,100
Vitamin E	mg.	6.6	14	19	28	38	22	55
Riboflavin	mg.	1.8	3.8	4.4	5.5	7.7	8	16
Niacin	mg.	13	22	24	25	35	40	90
Pantothenic acid	mg.	8	14	19	28	38	32	70
Vitamin B_{12}	mcg.	13	18	18	28	38	27	55

a. These requirements are based on United States National Research Council recommendations. See Table 1 for details.

Table 3 NUTRIENT COMPOSITION OF FEEDSTUFFS COMMONLY USED IN SWINE DIETS.

Energy Feeds	Dry Matter %	Protein %	Lysine %	Fat %	Fiber %	Digestible Energy kcal/kg.	Ca %	P %	Riboflavin mg/kg.	Niacin mg/kg.	Pantothenic Acid mg/kg.
Corn, yellow	88	9.0	.2	4.4	2.0	3,300	.01	0.27	1	26	4
Sorghum	87	9.7	.2	3.4	3.6	3,250	.04	0.30	1	43	11
Rice bran	90	12.0	.5	12.0	11.0	3,250	.06	1.50	3	300	24
Wheat bran	90	15.0	.5	4.0	8.0	3,150	.10	1.00	3	120	15
Banana tree	8	0.5	--	0.1	2.0	-----	.05	0.02	-	---	--
Rice, polished	89	8.0	.2	2.0	0.4	3,600	.04	0.20	1	14	4
Brown rice	89	10.0	.3	1.2	1.0	3,600	.04	0.18	1	17	5
Brewers grains, wet	23	5.0	--	1.6	3.6	450	.06	0.12	-	10	2
Brewers grains, dried	80	25.5	--	6.0	15.0	1,800	.27	0.50	2	43	9
Sweet potatoes, fresh	30	1.0	--	0.5	1.0	1,250	.03	0.04	1	10	-
Sweet potatoes, dried	90	3.0	--	1.5	3.0	3,600	.09	0.12	3	30	-
Wheat grain	90	12.5	.3	1.5	2.4	3,500	.05	0.35	1	60	13
Molasses, cane	78	3.0	--	0.0	0.0	2,500	.86	0.08	3	31	39
Sugar cane, stalks	27	0.7	--	0.4	8.0	500	.13	0.05	-	--	--
Cassava, fresh	35	1.0	--	0.3	1.5	1,200	.04	0.05	-	--	--
Broken rice	89	8.0	.2	2.0	0.4	3,600	.04	0.20	1	15	5
Broken brown rice -	89	10.0	.3	1.2	1.0	3,600	.04	0.18	1	17	5
Paddy or rough rice	90	7.5	.2	2.0	10.0	2,500	.04	0.26	1	30	8
Banana fruit, whole ripe	20	1.1	--	0.2	1.0	870	.08	0.28	1	6	--
Cassava, dried	88	2.5	--	1.4	3.0	3,400	.09	0.25	-	--	--
Garbage	13	3.0	--	5.0	1.0	500	---	---	-	--	--

Table 4 NUTRIENT COMPOSITION OF INGREDIENTS USED IN SWINE DIETS

Protein Feeds	Dry Matter %	Protein %	Lysine %	Fat %	Fiber %	Digestible Energy kcal/kg.	Ca %	P %	Riboflavin mg/kg.	Niacin mg/kg.	Pantothenic Acid mg/kg.
Coconut meal	90	20	0.5	6.0	10.0	3,000	0.17	0.60	3	25	6
Cottonseed meal, solv. extd.	90	41	1.6	2.0	14.0	3,000	0.20	1.00	5	40	8
Fish meal, anchovy	90	65	5.0	5.0	1.0	3,000	4.0	2.5	6	60	10
Fish meal, menhaden	90	60	5.0	6.0	1.0	3,000	5.0	3.0	5	55	9
Fish, whole dried	90	50	4.5	12.0	1.0	3,200	5.0	3.0	6	60	10
Meat and bone meal	90	50	3.0	8.0	2.5	3,000	10.0	5.0	5	48	4
Peanuts	90	30	1.0	44.0	2.5	4,400	0.06	0.44	8	150	40
Peanut meal, solv. extd.	90	47	2.0	1.2	13.0	2,850	0.20	0.65	11	170	50
Soybean meal, solv. extd.	90	44	2.9	1.0	6.0	3,300	0.25	0.60	3	27	15
Soybean meal, solv. extd.	90	49	3.2	1.0	3.0	3,400	0.26	0.62	3	27	15
Soybean seed	90	36	2.3	18.0	5.0	4,000	0.25	0.60	2	18	10
Yeast, torula, dried	93	48	3.8	2.5	2.0	2,470	0.57	1.68	44	48	39
Vitamin Feeds:											
Alfalfa, fresh	22	4.0	---	0.8	6.0	350	0.40	0.6	3	12	8
Alfalfa meal, dried	92	17.0	---	3.0	24.0	1,400	1.30	0.24	12	46	30
Elephant grass, napier	22	1.1	---	0.3	9.0	350	0.08	0.07	--	--	--
Kudzu, tropical	22	3.5	---	0.8	8.0	350	0.90	0.07	--	--	--
Cassava leaves, fresh	15	4.0	---	0.8	3.0	250	0.12	0.08	--	--	--
Water Hyacinth	10	1.0	---	0.3	2.0	130	0.[illegible]	0.05	--	--	--
Sweet potato leaves & vines	12	2.0	---	0.5	3.0	200	0.12	0.10	--	--	--

Table 5 PROTEIN SUPPLEMENTS FOR USE WITH TROPICAL FEEDSTUFFS

Ingredients		Formulas 1	2	3	4	5
		%	%	%	%	%
Cottonseed meal	(40% protein)	45		50		
Coconut meal	(20% protein)				40	
Peanut meal	(45% protein)		40			
Soybean meal	(44% protein)					70
Meat and Bone meal	(50% protein)	40	40	20	30	20
Blood meal	(80% protein)			10	20	
Rice bran or wheat bran	(12% protein)	11	16	11	3	1
Bone meal				5	3	5
Salt		2	2	2	2	2
Vitamin premix		2	2	2	2	2
Antibiotic premix		+	+	+	+	+
Trace mineral premix	(.25% of protein supp.)	+	+	+	+	+
Total		100	100	100	100	100
Calculated analysis						
Protein, %		40	40	40	40	41
Lysine, %		2.0	2.1	2.1	2.3	2.6
Calcium, %		3.6	3.3	3.2	3.2	3.0
Phophorus, %		2.7	2.4	2.2	2.1	2.0

Table 6 COMPOSITION OF VITAMIN AND TRACE MINERAL PREMIXES

Vitamin	Vitamin premix 1: Per pound of premix	Per kilogram of premix
Vitamin A, I.U.	400,000	880,000
Vitamin D, I.U.	40,000	88,000
Vitamin E, I.U.	2,000	4,400
Vitamin K, mg.	300	660
Riboflavin, mg.	400	880
Pantothenic Acid mg.	1,600	3,500
Niacin, mg.	2,400	5,280
B_{12}, mg.	2	4.4

Trace mineral premix 2: Trace mineral	Percent of premix
Copper	1.0
Iodine	0.04
Iron	10.0
Manganese	4.0
Zinc	10.0

1 Add to protein supplements at the rate of 2%.
2 Add to protein supplements at the rate of 0.25%.

Table 7 SORGHUM-PROTEIN SUPPLEMENT FEEDING PROGRAM FOR GROWING-FINISHING SWINE

Liveweight, kg.	10-20	20-35	35-60	60-90
Sorghum, 9% protein	71	77.4	84	87
Supplement, 40% protein	29	22.6	16	13
	100	100	100	100
Percentage Units of Protein contributed by				
Sorghum, 9% protein	6.4	7.0	7.6	7.8
Supplement, 40% protein	11.6	9.0	6.4	5.2
	18.0	16.0	14.0	13.0
Daily feed intake, grams	1250	1700	2500	3045
% protein recommended	18	16	14	13
Daily protein requirement, grams	225	272	350	455
Sorghum consumed daily, grams	888	1316	2100	3045
Protein supplement consumed daily, grams	362	384	400	455
Daily feed intake	1250	1700	2500	3500
Average expected daily gain, kg.	0.5	0.6	0.75	0.90

Table 8 MOLASSES FEEDING PROGRAM FOR GROWING-FINISHING SWINE

Liveweight, kg.	10-20	20-35	35-60	60-90
% protein recommended	18	16	14	13
Formula of diet				
Sorghum or Corn, %	48	40	32	24
Molasses, %	20	30	40	50
Protein supplement, 40% protein, %	32	30	28	26
	100	100	100	100
Daily feed intake				
Approximate daily feed intake, grams	1250	1700	2500	3500
Sorghum or corn, grams	600	680	800	840
Molasses, grams	250	510	1000	1750
Protein supplement, grams	400	510	700	910
	1250	1700	2500	3500

Table 9 CASSAVA FEEDING PROGRAM FOR GROWING AND FINISHING SWINE

Liveweight, kg.	20-35	35-60	60-90
Fresh chopped cassava, kg. daily			
Cassava, fresh copped, kg.	4.1	5.2	6.5
Protein supplement, 40% protein, kg.	0.7	0.8	0.9
Sun dried cassava, kg. daily			
Cassava sun dried, 90% dry matter, kg.	1.8	2.3	2.8
Protein supplement, 40% protein, kg.	0.7	0.8	0.9
	2.5	3.1	3.7
Sun dried cassava and molasses, % of diet			
Cassava sun dried, 90% dry matter, %	48	46	43
Molasses, %	20	25	30
Protein supplement, 40% protein, %	32	29	27
	100	100	100
Sun dried cassava and molasses, Same formula as above but based on daily consumption			
Cassava, kg. daily	1.2	1.42	1.6
Molasses, kg. daily	0.5	0.78	1.1
Protein supplement, 40% protein, kg. daily	0.8	0.9	1.0
	2.5	3.1	3.7

Table 10 BANANA FEEDING PROGRAM FOR GROWING-FINISHING SWINE

Liveweight, kg.	10-20	20-35	35-60	60-90
Daily feed intake on as fed basis, kg.				
Bananas, mature with skins, kg.	3.125	4.250	8.250	11.500
Supplement, 30% protein, kg.	.625	.850	.850	1.200
Daily feed intake on air dry basis, 10% Moisture, kg.				
From bananas, kg.	.625	.850	1.650	2.300
From supplement, kg.	.625	.850	.850	1.200
Total and amount required, kg.	1.250	1.700	2.500	3.500
Protein recommended, grams	225	272	350	455
Protein furnished, grams	218	297	337	475

Note: From 10-35 kg. liveweight one half of the feed requirement is from bananas. From 35-90 kg. liveweight two-thirds of the feed requirement is from bananas.