BY-PRODUCTS (MEXICO)
AN EVALUATION

Phase I - 3-P-73-0139
Phase II - 3-P-76-0064

RECIPIENT INSTITUTION: Consejo Nacional de Ciencia y Tecnologia (CONACYT)
Av. Insurgentes sur 1677
Mexico 20, D.F.

DURATION: Phase I - Nov. 1974 to Dec. 1976
Phase II - Jan. 1977 to Dec. 1978

IDRC CONTRIBUTION: Phase I - $307,650
Phase II - $396,200

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1. THE RESEARCH PROBLEM

1.1 Background

Mexico has a long history as producer of sugarcane and beef cattle. Thirty million tonnes of sugarcane are grown annually, with 70 per cent of the molasses production being exported and 90 per cent of the bagasse disposed as waste or burned. This is accompanied by a shortage of quality beef, domestic fluid milk, with increasing imports of milk powder.

Much of the sugarcane in Mexico is grown on cooperative farms (ejidos) or on small individually owned farms. The income of these sugarcane producers is reduced by an inefficient processing sector based on outdated technology and inadequate capacity. Similarly, the compesino (small farmer) with a few head of cattle must sell his animals at an early age and for a low price to the larger producer because he has limited resources and depends on the large producer as a non-institutional source of credit.

Mexican beef and milk production depends almost entirely on the quantity and quality of available pastures, with little intensive feeding. The average daily weight gain in cattle is at most 400 to 500 grams per day in the wet season and is often negative in the dry season. Tropical grasses of low nutritive value, a scarcity of cereal grains, and a shortage of pasture in the dry season are the main reasons for these low growth rates.

As early as 1970, Cuban scientists reported live-weight gains of 885 grams per day in commercial fattening systems, using high levels of molasses in combination with urea as feed. In 1973, research in Barbados showed that when derinded cane stalk was supplemented with chopped cane tops, protein, urea, minerals, and vitamins, it was capable of supporting live-weight gains in Holstein steers of up to one kilogram per day. The results of this previous research, combined with dry matter (35 tonnes per hectare), led scientists concerned with animal production in the tropics to recognize the potential of feeding cattle with sugarcane and its by-products.

1.2 Project Development

In 1973, the Director of Research of the Livestock Nutrition Project at the National Sugar Industry Commission (CNIA) and a group of university scientists presented a proposal to IDRC to study the use of sugarcane and cane products as animal feeds. As the original idea developed, the objectives were expanded beyond nutritional biochemistry studies and the encouragement of greater post-graduate training in animal production to comparative economic studies of the introduction of new technologies for the conversion of sugarcane and sugar by-products into animal feeds.

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1.3 Objectives

The specific objectives of the project are:

a) to develop cattle feeding systems which can make the most efficient use of sugarcane and cane products;

b) to develop and test systems by which to diversify the existing sugarcane industry and to determine if low-quality cane and cane being ground in small uneconomic mills can economically be directed into animal feed;

c) to study the biochemical consequences in ruminants of diets based largely upon sugarcane;

d) to determine the relative economic benefits of the alternative uses of sugarcane at different scales and under different conditions of processing and utilization; and,

e) to encourage post-graduate teaching programs in animal sciences.

The objectives of Phase II were similar to those in Phase I with a much stronger emphasis on on-farm testing, and an increase in the levels of milk production.

1.4 Recipient Institutions

Although Mexico has a large agricultural research and training infrastructure relative to other Latin American countries, the various institutions have tended to function in isolation in the past. The Mexican Government, concerned particularly with the independence of university research, set up the National Council of Science and Technology (CONACYT) in December 1970 to act as "advisor to the Federal Government in the establishment, instrumentation, execution, and evaluation of national policies of science and technology".

This project involved the collaboration of six institutions under the overall coordination of CONACYT which was to be the only contracting agency with IDRC. Since this concept of inter-institutional cooperation in research was a novel one in Mexico, a Technical Advisory Committee was established to facilitate coordination, comprising the program leaders in each of the separate project components, the project leader, and representatives from the National Sugar Commission (CNIA) and the Ministry of Hydraulic Resources. It was to be the basic decision-making unit of the project.

The National Autonomous University of Mexico, the leading research university in the country, was linked in this project with the National Institute of Agricultural Research (INIA) and the National Institute for Livestock Research (INIP), the two government research agencies responsible for crop and livestock research in Mexico.

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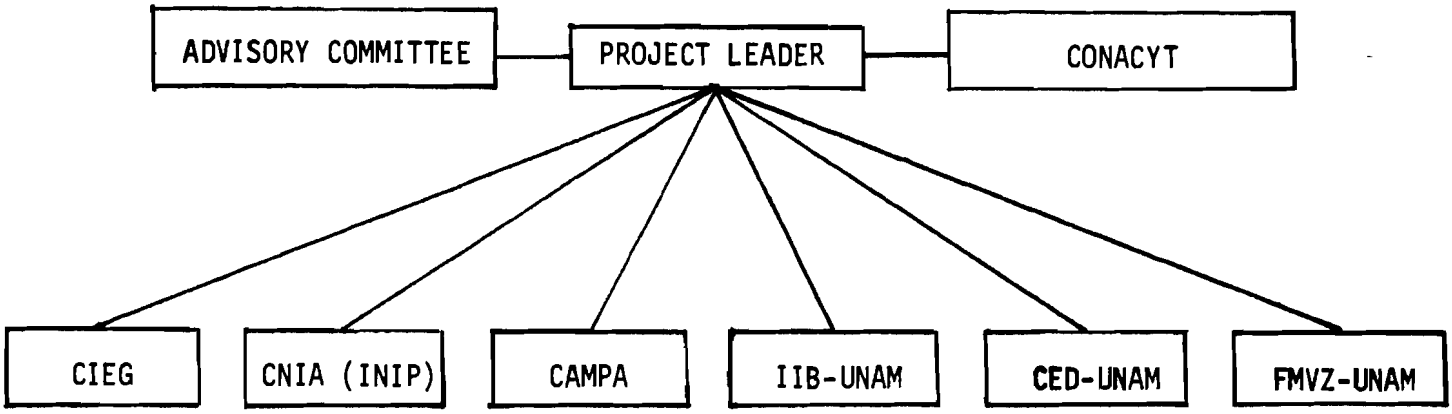
Figure 1



CIEG (Quintana Roo Territorial Government) - the development of feeding systems for production of beef and milk from molasses and derinded cane.

CNIA (National Sugar Commission) - research into the use of molasses, cane tops, bagasse pith and surplus cane for beef and milk production. CNIA was replaced by the National Institute for Livestock Research (INIP) shortly after the project commenced.

CAMPA (Training and Improvement Centre for Animal Production) - research into the use of molasses and sugarcane for beef production.

IIB-UNAM (Biomedical Research Institute of the National University of Mexico) - research into rumen microbiology and biochemistry.

CED-UNAM (Centre for Development Studies at the National University of Mexico) - economic evaluation of the data and feasibility of the alternative proposed technologies.

FMVZ-UNAM (Faculty of Veterinary Medicine of the National University of Mexico) - post-graduate training as a part of all the foregoing projects.

The project is broadly based with professionals drawn from a number of disciplines including veterinary medicine, agronomists, biochemists and agricultural economists with the largest component being veterinary medicine.

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2. PROJECT PERFORMANCE

2.1 Research Program

There are basically four components in this project:

a) basic research on biochemical techniques;

b) applied research dealing with beef and milk production;

c) economic research geared to assist the scientists; and,

d) post-graduate and non-degree training.

The experiments were initiated with some delays due to shortages of staff, research graduates, and lack of some equipment. In spite of the difficulties, the experiments of Phase I were completed on schedule and a five-month extension was granted to finish some training component on ruminants. Phase II is progressing according to plan.

2.2 Technical Achievements

In general, the results from Phase I are both encouraging and interesting in terms of defining the potential of sugarcane and cane by-products as feed for beef and dairy cattle. The results can be summarized as follows.

a) Several trials have demonstrated that there is no advantage in using derinded cane instead of whole chopped cane in terms of live-weight gain and feed conversion in beef cattle. Thus, in the absence of an economic use for the rind, incurring the expense of derinding equipment is not justified. It was also demonstrated that particle size of chopped cane ranging between 3 and 20 millimeters did not affect daily weight gains. In a feeding trial of beef cattle conducted in late 1974, it was shown that a locally made chopping machine (costing US$400) produced chopped cane that was more efficient in terms of average daily weight gain (615 grams per day) than the derinded cane (582 grams per day) produced by a much more expensive derinding machine (US$35,000). If confirmed, these results should be of considerable interest to CIDA which is supporting a major research program on the use of derinded sugarcane for cattle use.

b) Research has shown that the rumen fermentation process is strongly influenced by the amino acid composition of the diet. Sugarcane fermentation, whether spontaneous or as a result of ensiling, can generate various levels of acetic and butyric acids which tend to reduce voluntary intake. Results have shown that spontaneous fermentation is not a major problem in the dry seasons, but sugarcane silage must include ammonia at the time of ensiling or the high levels of

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both acetic and butyric acids will result. Although better than untreated silage, it is still not equal in quality when compared to freshly chopped cane.

Related to the fermentation problem, is the problem of toxicity in animals (often manifested by brain damage) as a result of a high sugar diet, especially one based on molasses. Fortunately, it has been possible to determine the level of toxicity in high molasses diets and now it can be prevented by the addition of dietary glycerine. This statement must be qualified though by stating that the complete understanding of this process and its economics will require further study.

The nutritional biochemistry studies have demonstrated that both the quantity and quality of supplements in high sugar diets are important. Rice polishings have been shown to give a consistent response in terms of voluntary intake, in diminishing the toxicity effects of a high sugar diet and in increasing live-weight gain by using as little as 100 grams per day on 13 kilograms of sugar.

The appropriate mix of supplements is important. Sugarcane supplemented with rice polishings without urea resulted in no significant live-weight gain, but with the addition of 35 grams of urea with every 1000 grams of dry matter, animals grew at almost 700 grams daily. Tests of sugarcane-based rations using native legumes (Leucaena and Ramon) as substitutes for commercial supplements show significant reduction in costs (up to 50 per cent of supplement costs).

c) The IIB has developed a liquid anaerobic fermentation process using a mixture of molasses, manure, urea, and various fibrous crop residues (including sugarcane bagasse). This has gradually been scaled up from the laboratory level to a pilot plant capable of producing 60 tonnes of semi-solid product per month. This product which is called Biofermel, when fed with pasture and a small concentrate supplement, has given daily weight gains of over 2 pounds a day in 450-pound cattle. An economic analysis suggests that under commercial conditions in a feedlot, the use of Biofermel might make it possible to reduce feeding costs by up to 30 per cent. On the basis of these preliminary observations (See Table 1 below), the IIB is collaborating with a commercial feedlot running 500 heads of cattle receiving the Biofermel diet.

In early 1977, an experiment was conducted using 50 per cent Biofermel and 50 per cent concentrate. Preliminary trials indicate that milk yields were 5.5 per cent and butterfat content 6.5 per cent higher than that achieved with a standard corn-based ration.

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TABLE 1

Economic Comparison of Biofermel with Commercial Control Feed[a]

	Average daily feed costs per head (in pesos)	Average daily weight gain (kg)	Costs per kg of live-weight gain (pesos/kg)
Control	8.70	1.168	7.448
Biofermel	6.08	0.989	6.150

[a]These results indicate a savings of 30 per cent in terms of daily feed costs per head and 17 per cent in terms of costs per kilogram of live-weight gain.

Generally, macro-economic analyses of the technological development of this project have been limited. This has been partially the result of the economics group emphasis on macro studies of the sugar and cattle industries in Mexico and partially due to the animal scientists' preference to develop and establish physical parameters of a new technology before making any socio-economic evaluation.

The objectives of Phase II represent a continuation of those in Phase I, but with a much stronger emphasis on testing the application of the technology. Most of the results of experiments performed in Phase II have yet to be received in final form, but what seems to show most promise is the development of an integrated pasture and feeding system in the tropics, with pasture being used in the wet season and cane in the dry season. Furthermore, sugarcane has shown itself to be an important supplement during the rainy season when the muddy condition of the fields does not allow the animals to graze the pastures to satisfy their nutritional requirements.

2.3 Institutional and Personnel Development

In Phase I, twenty-two students were involved in the project, two of these working for their Ph.D's and the majority of the remainder for their M.Sc.'s. In all cases, their thesis work was directly related to some aspect of the project. It is planned in Phase II to have thirty-three students involved, of this six carried over from Phase I. A number of the former trainees in Phase I are still working in the project or are attached to institutions (training, extension, and research) concerned with sugar and livestock production. It should also be noted that non-degree technical training accounts for 40 per cent of the total fellowships awarded.

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Initially, there were problems in the training program because it had not been customary for UNAM to recognize some of the collaborating institutions as approved training centres. Specifically, UNAM would not recognize thesis research work of a student undertaken at one of the other research institutes unless that student was supervised by a professor of UNAM who was also conducting research at the same research institute. An agreement was finally worked out between UNAM, CIEG, and INIP. The training program is now progressing well and is an example of how the project has encouraged inter-institutional cooperation.

2.4 Management and Program Planning

It was realized from the start by both IDRC and the participating agencies that this was an ambitious undertaking. In terms of management and administration, the project's successful operation required the continuous cooperation of eleven full-time researchers operating in six different research institutions in various parts of Mexico.

Due to the strong personalities of the various project components' leaders and the lack of any institutional cooperation in the past, project staff stated there was a tendency for the different research groups to work in isolation, independent of any other sub-project experimental activity. Furthermore, the original project leader, also in charge of one of the sub-projects, was unable to get along with several other sub-project leaders and their staff. This problem was largely solved by having the Advisory Committee select a new project leader from one of the universities who unlike the first project leader was seconded to CONACYT on a full-time basis to coordinate the project.

Subsequent to this appointment, it was decided by the project leader, CONACYT, and IDRC that in the case of a possible Phase II full responsibility for coordination would lie with CONACYT rather than the scientist coordinator. This has occurred in Phase II, and as of April 1977, the project has been fully integrated into the CONACYT structure and an agreement has been reached between IDRC and CONACYT that the objectives of Phase II be more tightly defined and monitored by both.

The organizational structure of the project has remained intact, but there have been changes in terms of the institutions involved. Shortly after the project began, the National Sugar Commission (CNIA) withdrew from active participation in the project but remained on the Advisory Committee in an observer capacity. In place of the Sugar Commission, the Livestock Research Institute (INIP), a branch of the Ministry of Agriculture, entered actively into the project, largely with the use of its own funding.

Since its inception in 1970, CONACYT has been involved in the elaboration of national directives for science and technology, and in

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supporting research and training for industry and the service sectors. Previous to this project, it possessed limited technical capability for selecting and/or monitoring research projects and little, if any, involvement with the agricultural sector. Thus, the project was somewhat alien to CONACYT's structure. The change of administration when the new President of Mexico assumed office in 1976 brought about important repercussions to CONACYT and consequently to the project. The Director of CONACYT was changed as well as all of its top management. The new management misunderstood the original purposes of the project and paralyzed the movement of funds for a period of four months. As of April 1977, the project has been fully integrated into the CONACYT system, by hiring a new project leader responsible to CONACYT and by developing a new coordinating system in which financial and administrative responsibilities are exclusively placed with CONACYT. Both project and CONACYT staff have indicated they felt these changes improved the coordination of the different project components and that CONACYT's capability to monitor and coordinate other research projects has been strengthened, although IDRC project staff believe it still lacks the scientific manpower to adequately initiate, monitor, and control similar research projects of this size.

2.5 Administrative and Financial Problems

While an agreement was reached between IDRC and CONACYT in early December 1974, CONACYT (acting as the sole contracting agency) did not finish signing agreements with the various institutes until July 1975. This was the result of not having the cooperation of CNIA and of their eventual decision not to participate in the project. CNIA felt that it, not CONACYT, should be the sole contracting agency.

Due to some difficulties in obtaining signed agreements from all the institutes involved, there was a delay of six months before all sub-project research was under way. This in turn led to delay in the purchase of equipment, and the recruitment and training of post-graduate students. Also during Phase I, there was a four-month delay in the movement of funds from CONACYT to the institutes. This was a result of the then new administration in CONACYT who wished to have more control over the project, and in doing so, reviewed the accounting procedures of the institutes and made what they felt to be, the necessary changes. It should be mentioned though, that in those cases where funds from IDRC to CONACYT were delayed, CONACYT continued contributing funds to the project to ensure the continuation of research in all of the sub-projects.

2.6 National Linkages

While two to the original participants dropped out of the project by the end of Phase I, it was an encouraging sign to see that this did not lead to the complete breakup of the project and that these vacancies were filled relatively soon by other interested institutions.

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Furthermore, while IDRC staff felt the institutions did not always work together in Phase I as closely as they might have, their willingness to sign an agreement for an additional two years, under a more centralized management system, indicates a sense of inter-institutional cooperation that was not present before the project started. Furthermore, new institutions have expressed an interest in this research area. The University of Chapingo, other departments in UNAM, and the Institute of Electrical Research (IIE)* have indicated their desire to work on or initiate parallel research projects.

Another promising demonstration of the interest shown by other Mexican agencies is the ongoing negotiations with the National Organization of Sugar Mills (ONISA) which has indicated its willingness to provide financial support once the IDRC project terminates.

The importance of continuing support for this kind of major inter-institutional research program is due to the realization by the scientists involved, that the examination and development of the most productive system of sugarcane utilization in animal feeding will take longer than the duration of the project, and will require the cooperation of various disciplines within the scientific community. IDRC staff feel that CONACYT probably provides the best guarantee that this kind of support will be available.

2.7 Regional Linkages

Linkages have been developed between different countries of Latin America, where sugarcane utilization for animal feed could be important. These linkages have been mainly in the areas of animal nutrition and the biochemistry of sugarcane utilization, and with such institutions as the Institute of Animal Science (ICA) of Cuba, the Dominican Centre of Livestock Research with Sugar Cane (CEAGANA), and the Centre for Research and Training in Tropical Agriculture (CATIE) in Costa Rica. Scientists from twelve countries have visited this project and a number of countries were present at the International Conference of Sugar Cane in Animal Production which was sponsored by the project in Mexico on 25-27 April 1978.

2.8 The Beneficiary

The project was intended to benefit the Mexican economy by upgrading the productivity of beef and milk production and to develop new markets for the sugarcane industry.

The methodology employed was not intentionally designed to develop new technologies suited primarily for the campesino or the small marginal sugarcane producer. The idea was to devise new technologies that would turn sugarcane and its products into animal feed.

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*To study the alternative uses of waste gas from biomass fermentation in the production of feeds and fertilizers.

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The economic evaluations were used only to determine the relative economic benefits of the alternative uses of sugarcane at different scales and under different conditions of processing and utilization, along with a macro description of the cattle and sugar industry. They were not conducted to highlight a specific technological package suited for a specific category of Mexican beef and sugarcane producers.

The majority of on-farm experiments to date have been carried out on large cattle farms and ejidos, and with at least 100 head of cattle, usually more. Nevertheless, technical and economic studies are now being conducted in marginal areas in order to assess existing technologies and the campesino's reaction to new technologies. Further in this area, IDRC is encouraging the economists involved to evaluate the operations of the smaller (believed to be uneconomic) mills presently grinding cane for the sugar production.

3. IDRC'S ROLE AND INVOLVEMENT

Given the history of institutional isolation in Mexico, IDRC staff were inevitably drawn into a complicated round of initial discussions on the responsibilities and role of each of the participating agencies in this project. CONACYT was selected by the institutions as the umbrella organization which, using the decisions of the steering committee, would monitor and control expenditures. CONACYT's inexperience in coordinating research projects led to certain administrative complications which were eventually straightened out as CONACYT assumed more responsibility for direction of the project.

IDRC staff felt that considerable diplomacy was required to monitor and ensure that each institution stayed within the agreed research program without undercutting the coordinating role that the steering committee and CONACYT were supposed to exercise. Some of the project staff felt that IDRC should have taken a more active role in the project such as helping to jointly organize and sponsor the recent international workshop.

4. BROADER DEVELOPMENT IMPLICATIONS

With the change in administration in 1976, CONACYT is apparently being given an increasing budget and mandate to coordinate university research.

This project was unique in that it was the first research project CONACYT had ever administered. They used this opportunity to develop a more systematic method of monitoring and auditing various other projects of this nature.

Similarly, there may be some important continuing benefits from the cooperation that developed in this project by university and government departments which have had a long history of isolation and competition between each other.

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It may be difficult to eventually develop a process for sugarcane utilization which the small campesino with only a few head of cattle can utilize but the potential benefits justify continuing research in this area. Sugarcane is a widely grown crop in the tropics and produces the greatest amount of energy per unit of land of any widely grown crop.

Low sugar prices have made cane production uneconomic in many areas whereas meat and milk demand is increasing faster than supply, resulting in a continual increase in prices.

APPENDIX A

Budget and Actual Expenditures

BY-PRODUCTS (MEXICO)

	PHASE I						PHASE II					
	YEAR 1			YEAR 2			YEAR 3			CUMULATIVE		
	Budget	Actual	% Spent	Budget	Actual	% Spent	Budget	Actual	% Spent	Budget	Actual	% Spent
Training	73,500	45,740	62.2	83,500	121,392	145.4	79,350	53,212	67.1	236,350	220,344	93.2
Research expenses	20,070	7,936	39.5	27,000	22,426	83.1	33,750	29,750	88.2	80,820	60,112	74.4
Travel	11,650	6,316	54.2	12,300	21,162	172.1	23,030	22,030	95.7	46,980	49,508	105.4
Capital expenses	36,200	20,953	57.9	17,000	38,659	227.4	44,540	41,967	94.2	97,740	101,579	103.9
Publication	1,600	-	-	1,600	1,145	71.6	7,450	1,950	26.2	10,650	3,095	29.1
Supplies & Services	13,898	6,409	46.1	16,548	11,783	71.2	17,022	14,877	87.4	47,468	33,069	69.7
Consultancy	9,000	4,000	44.4	13,500	57	0.4	1,500	-	-	15,000	4,057	27.1
TOTAL	165,918	91,354	55.1	171,448	216,626	126.4	206,642	163,786	79.3	544,008	471,766	86.7

APPENDIX B

GRAPH 1: BY-PRODUCTS (MEXICO)