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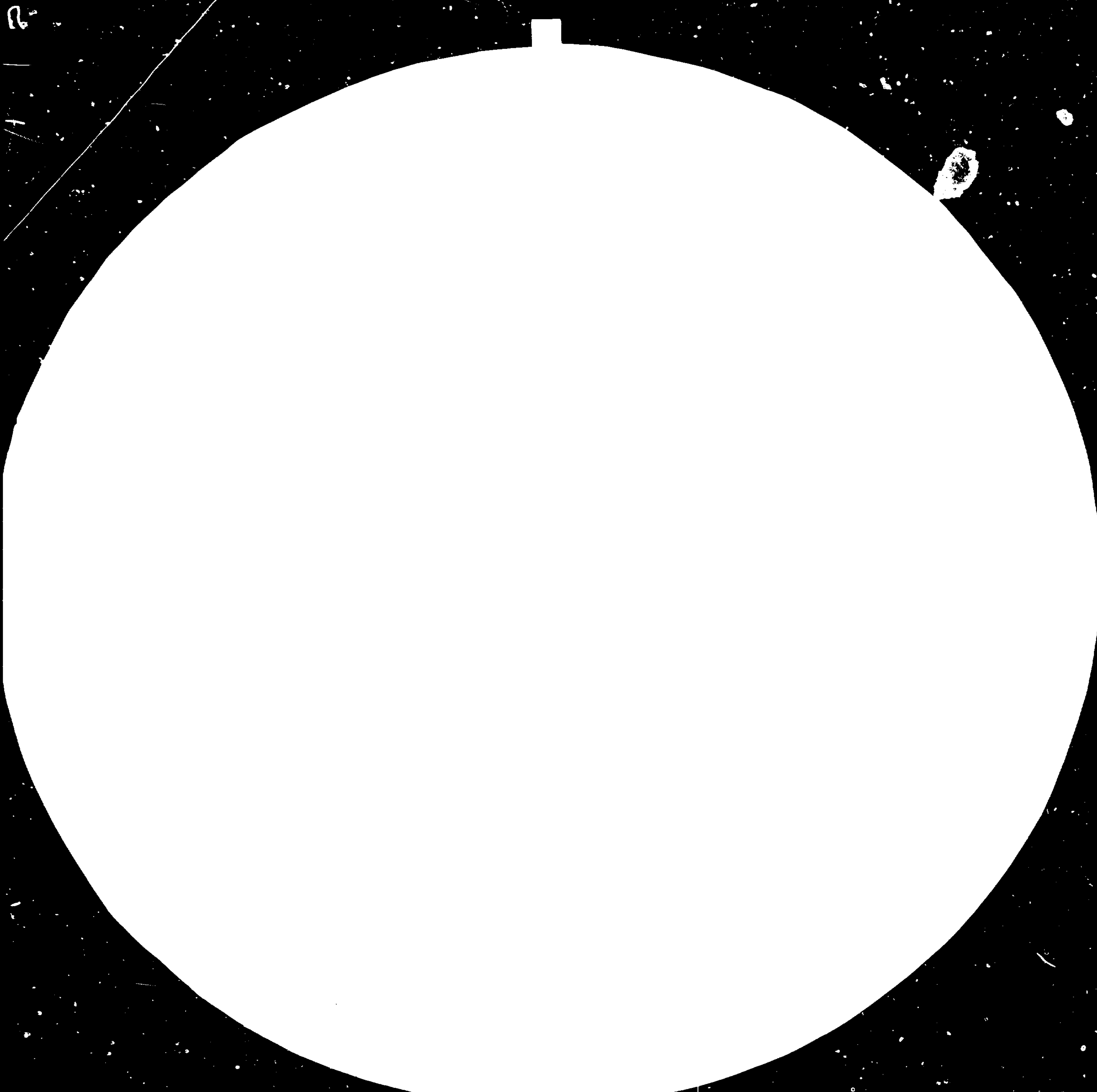

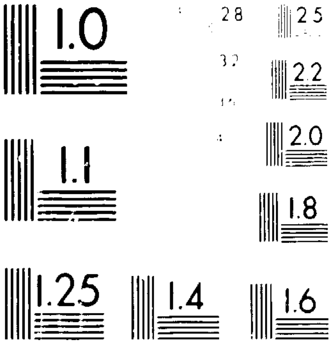

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BIOTECHNOLOGY FOR FOOD CONVERSIONS IN THE THIRD WORLD: DEVELOPMENT, TRANSFER AND IMPLEMENTATION*

by

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1.Why Biotechnology in the Third World?

Biotechnology is a modern discipline with important applications to the production of foods, feeds, fuels, chemicals and pharmaceuticals. It has already been used in large scale production of strategic biorganics such as antibiotics, aminoacids, vitamins and citric acid. Future applications in the field of fine chemicals, hormones, vaccines and plant clones are at various stages of development through the novel techniques of Genetic Engineering.

Important developments in the large scale production of microbial protein, gasohol (ethanol) and biogas (methane) have already taken place in Cuba, Brazil, India and China. Future developments in the Third World are being studied in subjects such as semisynthetic penicillins .insulin, compost from domestic residues and microbial enrichment of cassava (see for example the reviews published by the National Research Council of U.S., listed in the references)

More specifically the Third World faces crhonic problems related to inadequate food production and food processing systems, dependence on exportation of raw materials and importation of manufactured goods (Fig. 1) and problems of food distribution related to inequalities of family income among the various strata of the population (Fig. 2)

In respect to food production it is worth recalling the increasing problem of nutritional competition. That is, the conflict between direct human consumption and indirect animal production based on grain feeds. This competition is aggravated by the inefficiencies of animal conversion systems. For example, net conversion between grain feeds and animal food products varies from 46% in cows to 5% in beef cattle (Table I).

Most industrialized countries have used surplus grains for intensive animal production systems. This explains in large part the more efficient level of productivity for meat and milk observed in Europe, United States, Canada, USSR and Oceania, as compared with lower productivities of developing nations (Figs. 3 and 4).

Another aspect of nutritional competition is the fact that the upper economic stratum of the population consumes more animal products and reduces the availability of grains for nourishing the rest of the population, which has to survive in limited rations based on cereals and legumes.

Biotechnology can help to solve such kind of problems in food transformation. For example, new raw materials such as cassava and sugar cane can be transformed into balanced feedstuffs using microbial conversions of abundant tropical substrates (Table II).

In this paper, the case of Biotechnology for food production as developed, transferred and managed in Mexico will be discussed as an example from which some general propositions could be developed for similar regions of the Third World.

2. Identification of a Problem: What to Do and What For?

Looking at the potential applications of Biotechnology in food conversions of Mexico we can obtain some examples of problem identification. A summary of such kind of conclusions was recently published under the title: "More food but for whom?" (Viniegra-Gonzalez, 1982b). there it is pointed out that nutritional competition mentioned above, is a central problem of the food system of Mexico and probably of many other developing nations.

The economic basis for nutritional competition is the revaluation of food after animal conversion, despite the net loss of nutrients (Table I). In such a case, market forces are against adequate food nutrition because of the inequality of income distribution (Fig. 2) that tends to concentrate animal products in the upper economic strata as mentioned above. Also, recent currency devaluations add to the inequalities of income distribution and make more difficult to produce and distribute milk and meat for the majority of Mexican population.

Among the various alternatives it is possible to conceive the idea of using Biotechnology as a conversion factor acting on agricultural by-products such as molasses, corn stover and cane bagasse as substitutes of grain feeds in cattle fattening which is one of the most inefficient systems of animal conversions (Table I).

Future large production of cassava meal, plantains and other starchy products could be used as fermentation substrates in order to produce alternate raw materials instead of cereal grains and soya beans for animal nutrition, these in turn could be oriented for direct human consumption.

Microbial food conversions can be developed in various ways:

a) Improving the efficiency of rumen digestion of cows and beef cattle using pretreated feedstuffs (Dyer et al., 1975; Jackson, 1978), adequate blending of roughages with urea and molasses (Moller, 1982) and reorientation of rumen fermentation by massive and continuous inoculation of feedstuffs (Perez-Gavilan and Viniegra-Gonzalez, 1976)

b) Changing carbohydrate to protein ratio of tropical feedstufs, by means of submerged (Preston and Munoz, 1971)or solid cultures of microorganisms (Raimbault, 1980)

c) Increasing the quality of feed protein by means of lactic fermentation of grain meals (Rhodes and Orton, 1975)

A brief list of alternatives presently sudied in Mexico is given below:

a) Blending of molasses and urea with corn stover (Viniegra-Gonzalez, et al., 1982)

b) Lactic fermentation of molasses and urea blended with corn stover (Alvarez et al., 1979)

c) Bacterial conversion of corn stover into protein concentrate (De la Torre, et al. 1980)

d) Caustic pretreatment of corn stover (SARH, 1982).

e) Enrichment of cassava meals by solid fermentation using mold strains from native processes (Revah et al., 1982)

Each one of these alternatives has been investigated locally. In each case, there was some degree of adaptation of existing technologies around the world and this way local expertise was gained for appropiate transfer to the productive sector. Sometimes, adaptations changed the degree of mechanization, for example, changing from aseptic to non-aseptic fermentations. Other times, local machinery was adapted to a given process.

Therefore, a list of solutions was provided and this has been summarized in a National Symposium related to the use of agricultural by-products (SARH, 1982) and in a recent catalog of Mexican research communications on food technology (SEP, 1983).

Hence, it remains an important problem of alternative analysis for the application of Biotechnology to the general problem of reducing the competition between human and animal nutrition.

3. For Whom and What type of Biotechnolgy?

a) Who are the potential users of Biotechnology in the Third World?

Analysis of alternatives of a given technology has to be done in terms of their potential users. More precisely, for applying Biotechnology to food conversions it is important to recognize the different type of users related to food production and food processing.

Peasant economy is the basis for producing a large fraction of food utilized by the urban sector of developing nations. For example, in Mexico, cereal grains, sugar cane and oil seeds are mainly produced by the so called "social sector". Therefore, it is important to recognize the potential market of peasant organizations interested in food conversions.

On the other hand, there are also large enterprises related to food processing in the Third World. In some cases they belong to the private sector, in other instances they belong to the public sector. At any rate, they have similarities in relation to the scale of operation and their degree of centralization but they have different objectives and ways of operation.

There is a tendency for large enterprises of the private sector to concentrate on the processes related to high levels of profitability. For example, production of industrialized bread, coffee powder, soft drinks, animal feedstufs, milk powder, canned foods and alcoholic beverages. They try to maximize profits using modern marketing and controlling prices of raw materials and final products.

Large enterprises of the Mexican public sector are concentrated in the production and distribution of intermediate raw materials such as: wheat flour, coffee beans, cereal and oil grains, refrigerated and semiprocessed milk and sugar. They act as intermediates between a large number of peasante units and a small number of centralized units of the private sector. Their profitability is low and help to stabilize the price of such intermediate raw materials.

Small and medium size units of the social sector belong to cooperatives, communal enterprises or to small entepreneurs. They are concentrated in the production of traditional foods such as, local bakeries, corn "tortilla" factories, regional candies, small animal farms, etc.

b) What kind of Biotechnolgy is required by each type of user?

It is clear that each given case of user requires a different kind of technology.

-- Large private enterprises are mostly interested in capital intensive projects. In this way they can reduce labor costs, rationalize concentration of raw materials in a few processing units and optimize monopolic practices in marketing.

-- Large public enterprises tend to operate on the basis of political and social considerations. They often sacrifice their profits in order to accomodate raising prices from the social sector and the practice of lobbying for lower prices by the private sector. Often they act as the sources of important subsidies for large scale production of industrialized bread, soft drinks, animal feedstufs and alcoholic beverages.

-- Small units tend to make optimal use of local man power with scarce capital resources. They tend to integrate their production with local or regional marketing and depend on market fluctuations.

This brief description of Mexican agroindustries seems to justify the need of different approaches in applying Biotechnology to different kind of users interested on food conversions.

In the case of substitution of feed grains by fermented raw materials very little interest will be found in the private sector if there is a subsidy for conventional feedstuffs based on sorghum and soya beans. Their activity is related principally to poultry production which is the most concentrated and industrialized line of animal husbandry in Mexico. Therefore, their interest would depend on the possibility of reducing costs of raw materials and would be the result of national scarcity for grains combined with a policy of reducing subsidies for imported feedstuffs plus the creation of incentives for using new materials.

The public sector would be interested on reducing its foreign debt related to credits for importing grains, machinery and technology. This sector is in fact developing large scale production of aminoacids using Japanese fermentation technology. It is also considering various schemes of large scale production of single cell protein (SCP) based on methanol fermentation. Their major criteria for project evaluation would be related to strategic considerations of food marketing both with the exterior (reducing grain imports) and with the interior (reducing subsidies for feedstuff production).

The social sector would be interested in medium scale projects which could be integrated locally with available raw materials for increasing their added value by means of the conversion of agricultural excedents or by-products into animal products such as meat and milk and some of their derivatives. Biotechnology in this case has to operate with profits at low breaking even points. It should not require sophisticated levels of technology and has to have wide levels of reliability.

Being more specific in regard to the applications of Biotechnology to food conversions:

-- Private enterprises are now more interested in sophisticated products for human consumption, such as, yeast for beer and bread production and also in flavor compounds such as glutamate and nucleotides.

-- Goverment companies are now interested in large scale production of strategic raw materials such as lysine, threonine and SCP from methanol.

-- Enterprises belonging to the social sector are not very much aware of the potentials of Biotechnology for food conversions but they might be interested in using non-aseptic fermentations for silage and solid state enrichment of tropical products such as cassava, waste bananas and agricultural residues.

Those examples help to illustrate the great importance of appropiate identification of the users and their mode of operation. They also seem to support the need of developing national policies for Biotechnology in terms of the relationships between different kind of users and their potential linkage to national goals such as self reliance in food production, processing and distribution.

4. Biotechnology for the Private Sector.

a) Direct transfer or transfer with local development?

A limited number of private fermentation industries related to food conversions have been working in Mexico during the last 20 years. They have been producing baker and beer yeast, citric acid and yeast autolysates.

Those industries have used imported foreign technology with very little investment in local R and D. Their staff has received mostly "on the job" training and they have managed through the years to adapt and trouble shoot their processes.

Most of those private industries were created when Mexican currency was strong and it was easy to hire foreign biotechnologists as part time consultants or transient scientific supervisors.

Besides, the national policy of substitution of imports favored the indiscriminate use of foreign technology and equipment because of the protection by heavy importation tariffs of final products, with disregard to cost minimization. Also, official requirements on quality control and productivity were very loose. Therefore, private enterprises did not have incentives for developing their own technology.

Although there is no information on the nature of R and D activities done by the private sector in Biotechnology there are some cases who have been known by the author and might serve as examples of those activities.

A case was the operation of an antibiotic fermentation plant owned by a foreign enterprise but staffed only by Mexicans. This industry has had a very effective program of academic training for all the workers, who have been receiving biochemical and microbiological short courses in order to inform all personel about the basic principles of industrial fermentation.

As a result of such program, local engineers used available fermentation data for statistical correlation. They found two intriguing aspects of their process: power breakdowns and bacterial contamination sometimes improved the yield and quality of their products.

A careful analysis of this question seemed to indicate that partial anaerobiosis in a specific stage of fermentation was in fact a good thing to do. Also, bacterial contamination derived from certain local substrates was also a beneficial factor for their process.

This was the case where local problems of electric black out and low quality of raw materials were in fact the source of novel aspects of a sophisticated technology. This novelty was used and investigated later on by the foreign company and involved some improvements of the former process.

This, in turn, is an interesting case where local R and D capability produced good results with transfer of technology between a country of the Third World and an industrialized country.

Another case was related to a fermentation industry owned partially by a national society and partially by a foreign company. This company did not have a commitment for advanced training of engineers and workers of the fermentation plant. The transfer of technology was done directly by foreign technologists reporting to the production manager and there was practically no local R and D investment.

As a consequence of this policy, many problems were found during the adaptation of foreign microbial strains to local raw materials. Trouble shooting was difficult and corrections of equipment design sometimes were erratic. During various years the yields were below economic feasibility and finantial losses were problably greater than savings due to lack of local R and D.

Finally, the plant hired a national consultant in Biotechnology with advanced experience in R and D. He helped to develop better working conditions and also made easier the communication between the foreign consultant and the local manager.

Those two cases seem to indicate the need for having specific educational programs for fermentation industries, together with local investment in R and D in order to analyze production activities and to establish laboratory and pilot plant activities for effective trouble shooting and process development.

b) Relations between industries and research institutions.

In order to create the linkage between R and D and industrial production, two major programs were initiated by Conacyt (National Council of Science and Technology) more than eight years ago:

-- The Program of Shared Risk, where Conacyt risked 50% of R and D costs and industries risked the remaining 50%. If the R and D contract was succesful, private companies were asked to pay Conacyt's investment in the form of soft loans with very low rates of interest. Otherwise Conacyt reserved the property rights of such development.

-- The informational service called Infotec which did surveys and bibliographic analysis for national enterprises.

The second type of service was the most succesful. It helped to create interest of small and medium size companies on the existence of technological information useful for process improvement and also for considering new developments.

The program of Shared Risk created a publication called "Enlace" ("linkage") which has been advertising supply and demand of national technologies, some of them in the field of Biotechnology. This way national enterprises and research institutions had a public medium of communication.

Despite those advantadges of the Shared Risk program, very little interest was shown by private industries during the first 10 years of operation. This was probably due to the lack of incentives for local technology which were discussed above.

Nevertheless, strong devaluations of Mexican currency after 1980 have changed the oportunity cost of local vs. foreign technology and there are some indications of increasing demand of Biotechnology projects by private enterprises related to Biotechnology.

A dynamic field for food industry is product development for substituting for animal products by other sources of protein. This is due to the inflationary process affecting animal production and the lack of response of the production system based on imported feed grains.

Among the various alternatives for substitution, food additives have been considered to be produced locally. For example meat flavoring agents such as glutamate, nucleotides and yeast extracts and these changing trends of food production might be the basis for increasing the interest of private firms in signing contracts with research institutions.

Investment on R and D for process and product development is not sufficient for linking succesfully private industries with research institutions. It seems necesary to have a solid tradition in engineering. This has been a serious shortcoming of Mexican Biotechnology, because the local engineering firms usually do not have expertise in Biotechnology.

Recently, half a dozen engineering firms speciallized in various aspects of Biotechnology have been created in Mexico. Most of them have involved part time activities of university professors since Biotecnnology was initially developed in research institutions.

Practical experience of those firms have encountered serious problems of survival because of the shortage of new projects during the recession occurring after 1982 but there are some indications of new activities at the end of 1983.

In this sense it could be said that Mexico has now some attractive conditions for a strong development of Biotechnology applied to industrial production. They could be summarized as follows:

-- Institutional development in at least half a dozen research groups with projects oriented mainly towars food conversions and farmaceutical production.

-- Economic advantadges for national companies investing on R and D for local production in the field of new raw materials for food industry, including microbial proteins and flavor compounds.

-- Incipient development of local engineering firms specialized in Biotechnology.

-- Goverment incentives for R and D oriented to food production, including subsidies for R and D and information services.

As a conclusion, the recent experience of Mexican Biotechnology seems to indicate that development, transfer and implementation of such industrial projects needs an scenario made of the elements discussed above. Otherwise an incomplete cycle of R and D would result inefective although it might be accompanied by interesting academic publications.

5. Biotechnology for the Public Sector

Recent developments in Cuba and Brazil for large scale utilization of sugar cane in microbial protein and gasohol, respectively, seem to agree with the need of stront commitments of a National Goverment as a fundamental incentive for the application of Biotechnology to the solution of serious problems of shortage of raw materials.

In Cuba, there was a strategic reason for developing a large scale system for intensive animal production without imported cereal grains. The large surplus of cane molasses was the basis for starting the production of Candida yeast in Ciro Redondo, using French technology but operated by local staff. Also the scarcity of local or imported feedstuffs served as an incentive for using such technology.

An account of the Cuban production of Candida yeast has been reviewed by Monry and Viniegra (1981). Here it is interesting to mention various aspects of the actual transfer of technology that took place during the end of the sixties.

The operation of the first fermentation plant encountered a serious obstacle. It was designed for temperate weather and did not have provisions for cooling the large fermentation vessels amounting 60,000 liters of volume and operated as airlift open continuous reactors.

The French firm involved in the design, erection and start-up of this new factory decided to pay the fine for not complying with the dates and conditions of operation instead of trying to solve the problems of faulty design.

It was necessary for the Cuban research workers to do some work at the ICIDCA (Instituto Cubano de Investigaciones sobre los Derivados de la Cana de Azucar). They found that the yeast culture operated at 42 C had a very high maintenance coefficient and for that reason it was necessary to redesign the blowers with higher power than the power of the blowers designed on the assumption of temperate weather operation.

Final start-up of Ciro Redondo's factory also showed many other problems related to foam production, break down of sophisticated controls, large costs of yeast drying and indigestibility of crude organisms.

New factories have been redesigned in order to avoid such problems with a national project of six factories for the large scale production of feedstufs for swines using cane molasses as the main raw material for supplying both energy and substrate for microbial protein. This system has been shown to be a valid alternative for intensive meat production (Velazquez and Preston, 1970) and is now the basis for large scale supply of pork meat in Cuba.

In this case the national commitment for financing development of an strategic production system was the major working factor. It also involved some lines of international cooperation. For example, the transfer of French and also Austrian technolgy for large scale fermentation, the scientific advice of Eastern German and Czeck biotechnologists advicing ICIDCA for understanding the problems of continuous fermentation and the cooperation with animal nutritionists from Scotland advicing Instituto de Ciencia Animal (ICA) was involved in the novel use of molasses as the main animal feed in swine and beef production.

Therefore, it is important to point out the great value of adequate and oportune govermental decissions for the application of Biotechnology in the production of strategic products such as microbial protein, liquid fuels and chemicals. Furthermore, adequate transfer and absorption of technology seems to be a useful way of solving national food problems of the Third Worls.

In conclusion, Goverment decissions on the production of strategic products have to be oportune in time and linked to important investments on local R and D in order to insure effective transfer and management of Biotechnology.

6. Biotechnology for the Social Sector.

a) Identification of priorities

Many Latin American farmers and peasants share a common problem, lack of integration between animal and plant production. This is due in large part to the Colonial heritage of extensive animal farming promoted by Iberic colonizers. As compared to the intensive farming developed in Central Europe and Great Britain during the XVII and XVIII centuries.

As a consequence of this historical problem, farming in tropical regions of our Continent has been related to inefficient cycles attached to the raining and drought seasons that impose serious limitations on animal production. Those defficiencies are reflected in the low produtivity of meat and milk of many regions of the Third World (Figs. 3 and 4).

Added to this problem, the importation of nutritional technology based on cereal grains produced in temperate regions imposed the need of importing large quantities of those materials and inhibited the use of local raw materials such as cassava and sugar cane that seem to have good productivity in tropical lands (Table II)

Substitution of cereal grains for tropical products has a serious shortcomming: their very low content of protein which in turn would require importation or local production of soy beans or microbial conversion of tropical substrates.

The feasibility of both approaches for swine production has been discussed recently (Viniegra-Gonzalez, 1982a). The major argument is based on the fact that animal production -- for example, swines -- require more energy than protein because the energy conversion ratio is of only 12.3% whereas, the protein conversion is of 20.4%. Thus, the use of a crop such as cassava with very high energy yields (under intensive farming conditions) can overshoot the neeed of sacrificing part of the area for soy beans or for using part of the crop for microbial conversions (Viniegra-Gonzalez, 1982a).

Development of this alternative in tropical regions of the Third World can be a turning point for overcoming low meat productivity indicated in Fig. 3. It is worth recalling here that China has developed higher meat productivity thanks to their peculiar intensive farming using swines as the major domestic animal.

Also it should be noted that areas appropiated for intensive production of crops such as cassava, sweet potatoe, plantains and sugar cane, are not necessarily good for producing cereal grains and oil seeds. Therefore, it is necessary to search for alternate schemes of intensive animal production, perharps using microbial conversion as a key element.

There is however a technical problem, the fact that current technology for microbial protein production is based on submerged cultures which in turn requires large output volumes for reaching the break even point of operation. For example, they would require at least 10,000 hectares of cassava or sugar cane.

Therefore, one of the priorities for the Biotechnology applied to the tropical regions of the Third World is the scaled down of microbial conversions. This in fact seems to be possible using solid state fermentations described by Raimbault (1980).

Other research priorities are in the field of food and feed conservation using lactic fermentation instead of expensive drying operations (Gomez and Viniegra-Gonzalez, 1981). Also, the up-grading of traditional fermentations could be the basis for food processing at farm level.

A typical case of lactic fermentation is the conversion of raw milk into sour milk and cheese. This conversion seems to be necessary for local consumption of milk derivatives by adults in the Third World because of the prevalence of lactose intolerance.

Food processing at farm level is of great importance for improving net profits because small farming units ussually do not sell their raw materials at a good price. Field analysis of cattle farming in Mexico has shown that cheese making is precisely the type of technology that is suitable for improving the economy of small animal farms (Viniegra-Gonzalez, unpublished results)

These brief considerations justify the application of at least two kinds of Biotechnology processes useful to the social sector of the Third World: solid state fermentation and lactic fermentation.

b) Participation of users in the R and D cycle.

Practical experience on rural extension of Biotechnology in Mexico has indicated the importance of user participation during the R and D cycle.

The peculiarities of each region and community very often make ineffective the application of technologies developed in the central laboratories of research institutions.

It is necessary to have direct access and communication to the actual problems of peasant communities and for doing such it is needed that research workers involve themselves in some aspects of rural education.

Otherwise, a fine process developed in a research institution could be rejected by peasants. Sometimes the notions of research workers on the availability of skills or machinery are based on fantasies and misconceptions. Some other times the labor requirements of a given process might not be adequate for integrating to traditional farming. Finally, social and political constraints often make impossible the construction and operation of cooperative factories.

Therefore, it should be concluded that research groups engaged in the application of Biotechnology to the social sector of the Third World shoud be related to some form of extension services that open a line of communication between the potential users and the research group.

c) From lab-scale to field demonstration.

The preceding section opened up the question of the internal transfer of technology between research groups and actual users.

Past years of extension work have indicated the need for at least 7 stages of the R and D cycle.

-- Field work in order to obtain first hand information on the local conditions of the potential users. This would enable to visualize the type of organization and physical scale appropiate for final application of a given technolgy.

-- Research work at laboratory scale in order to understand the constraints and possibilities of a new technology and also in order to define the possibilities for actual process design and operation.

-- Pilot development in research laboratories in order to construct and operate physical prototypes and for testing the reliability and technical features of the new process. At this stage it would be necessary to have an economic evaluation and it would be useful to check results with actual needs at farm level.

-- Pilot demonstration in an experimental field in order to verify the reliability of the new process when it is operated in actual weather conditions and using local technicians to be trained for extension work and trouble shooting.

-- Field demonstration in a real community with a program of on the job training of users with follow up of results and problems.

-- An extension program using the field demonstration as a training facility and promoting the active participation of local technicians and users as the major educational factor for new users.

This methodology is now being applied to various regions of Mexico in the following technological packages:

-- Intensive cattle fattening using molasses, urea and corn stover as a major ingredient in the feedlot (Viniegra-Gonzalez, 1982)

-- Production of cane syrups in small factories (Viniegra et al., 1979).

-- Peanut processing using traditional technology (Viniegra, unpublished results).

In conclusion, a specific methodology for R and D is recommended when applied to the social sector of the Third World, this involves close contact and cooperation with the users by means of combining laboratory and pilot work with field extension programs.

7.) Appropiate transfer of technology by means of international cooperation.

International cooperation could be an important way to accelarate the advancement of Biotechnology in the Third World. But it requires a special methodology.

Previous discussion on the internal transfer of Biotechnology seems to indicate the need for sensitizing internationals foundations and cooperating bodies of industrialized nations on the nature, potential and limitations of such kind of cooperation.

Experience with the Organization of American States, International Development Research Centre (Canada) and the Office of Recherche Scientifique et Technique Outre-Mer (France) has indicated the following basis for international cooperation in Biotechnology in the Third World.

The foregoing sections have stressed the need of reinforcing local R and D capabilities. Here it is recalled that some international schemes have placed the emphasis on the creation of international centers operated by foreigners in various countries of the Third World. It is worth recalling that it is an inefficient way of getting acquainted with the field problems of those regions since cultural barriers and prejudices often obscure the understanding of the technological development in terms of the local social and economic conditions.

The author favors the scheme where funds for managing cooperative projects are allocated on the basis of agreements with local biotechnologists. Scientific advice could be given and should be welcomed, specially when the responsible inventor or the senior research worker is allowed to stay for a long period of time as an acting member of the resarch team. But final responsability for execution and application should be on the shoulders of local investigators.

As an example of this kind of cooperation, it is worth mentioning the present agreement between UAM and ORSTOM for codevelopment of the solid state fermentation process in Mexico. In this project, the senior investigator from France (Dr. Maurice Raimbault) has been allowed to stay for 3 or 4 years in Mexico.

Active and direct participation of a visiting investigator allows him to understand many of the local constraints for Biotechnology development. Also, advanced training of Mexican graduates helps to strengthen the R and D local capabilities and helps to develop a two way cooperation during the actual cycle of technology development.

As an example of the benefits of this joint project, it could be said that:

-- An interdisciplinary research team has been organized with seven Mexican Associate Professors studying various aspects of solid state fermentation, including, selection of native mold and lactic strains of microorganisms, development of lab and pilot equipment for solid fermentations, studies on the secondary metabolism of molds and applications of lactic fermentation to the conservation of starchy foods.

-- An active exchange program was organized for advanced training of two Mexican Professors who have started research projects in French laboratories as part of their sabbatical leave and also oriented to specific aspects of their local research projects. In reciprocity, two other French scholars will be trained in Mexico on some aspects of lactic and solid state fermentations.

-- Furthermore, a limited number of young Mexican graduates are being trained locally in short term projects of laboratory research and pilot work in such a way that they could be hired for industrial work or continue for advanced post-graduate training abroad or within the country.

-- Finally, communication with colleagues of some countries of Central America and the Caribbean area is creating a small network of cooperation within countries of the Third World interested in R and D for solid state fermentation.

In regard to other foundations, it should be said that investment in local R and D groups and close collaboration between countries of the Third World with some external cooperation seems to be the most appropiate way of establishing international cooperation. Recent experience with the creation of short term project of OAS has indicated the efficiency of this approach within the scope of the so called "Mar del Plata Program". The activities of IDRC for supporting local research throughout Latin America have also shown efficiency and have helped to develop local institutions and cooperation within the region.

In conclusion, the major emphasis of international cooperation in the Third World should be the support and improvement of local R and D groups. Responsability for managing research projects should be for local investigators. Codevelopment of new technologies seems to be an appropiate way of transfering know-how and research capability if it is planned on the basis of reciprocal cooperation and mutual benefits derived from final industrialization.

7.Summary of Conclusions.

a) Biotechnology could be of great importance for reducing competition between human and animal nutrition in the Third World.

b) Appropiate users identification and characterization belonging either to the private, public or social sectors are necessary for adequate development, transfer and implementation of Biotechnology.

c) Educational programs for technical staff and R and D investment are necessary in order to insure effective technology transfer.

d) Oportune Goverment commitments together with substantial financing of R and D projects related to microbial conversions are necessary for reducing the shortage of protein materials in the food and feed industry of many countries of the Third World.

e) Active participation of users and special methodology for technology transfer, including international cooperation, are necessary for effective application of Biotechnology to the Third World.

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TABLE I

ESTIMATED FOOD YIELDS OF SEVERAL AGRICULTURAL SYSTEMS

SYSTEM	T/HA	GCAL/HA	KG PROTEIN	$ US
44% Maize and 56% soya	3.0	8.8	702	750
Milk (2 cows x 3500 l)	7.0	4.1	245	1,826
Eggs (18,462 units)	1.2	1.6	119	1,264
Swines (8 heads)	0.8	1.0	85	1,064
Steers (3 heads)	0.4	0.4	35	457

Source: G. Viniegra-Gonzalez et al. (1980)

TABLE II

COMPARISON OF YIELDS BETWEEN MAIZE, SORGHUM, CASSAVA AND SUGAR CANE IN SELECTED COUNTRIES

Country	Maize	Sorghum	Cassava	Cane	Molasses	Bagasse
	(Yields in digestible matter tonnes/hectare)					
Peru	1.28	1.36	2.07	21.8	3.62	12.8
Ethiopia	0.88	0.56	--	21.6	3.59	12.7
Uganda	0.88	0.89	0.66	13.8	2.24	8.13
Taiwan	1.82	1.28	2.88	11.0	1.83	6.48
Ecuador	0.40	--	--	10.4	1.73	6.13
Jamaica	0.96	--	0.40	10.4	1.73	6.13
Mexico	0.96	2.00	--	9.4	1.56	5.54
India	0.80	0.40	2.35	7.2	1.20	4.24
Kenya	3.44	0.64	1.17	7.0	1.16	4.12
Range	0.9-3.4	0.4-2.0	0.4-2.9	7.0-22	1.2-3.6	4.1-13

Source: Preston and Willis (1974)

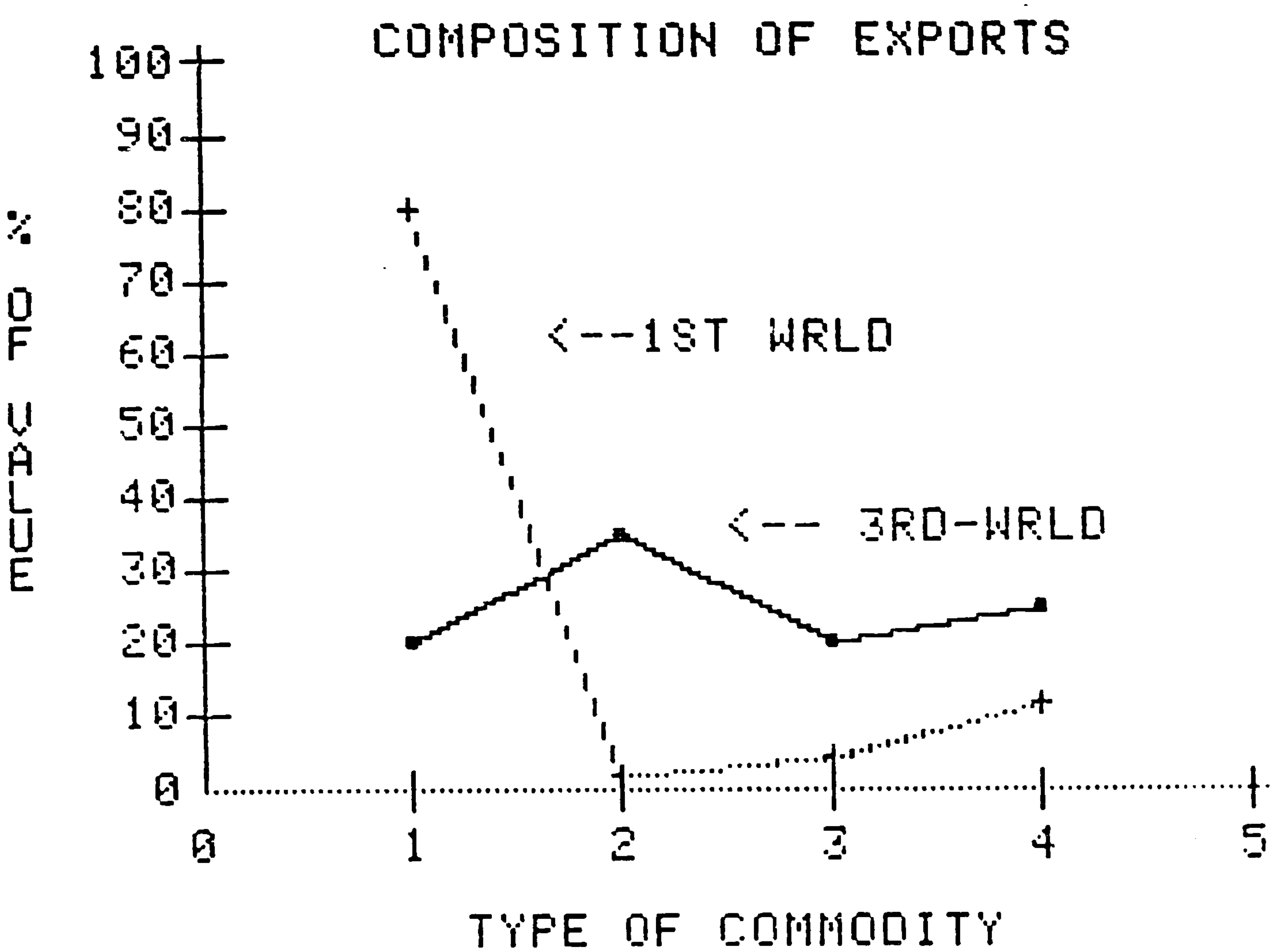

Fig. 1. Distribution of exports according to type of commodity: 1. Manufactured goods. 2. Fuels. 3. Raw materials. 4. Food products. Both in capitalist advanced countries (1st-World) and developing countries (3rd-World).

Source: P. Jalee "Le tiers monde in chiffres" (Spanish version) Edit. Fundamentos. Caracas (1971).

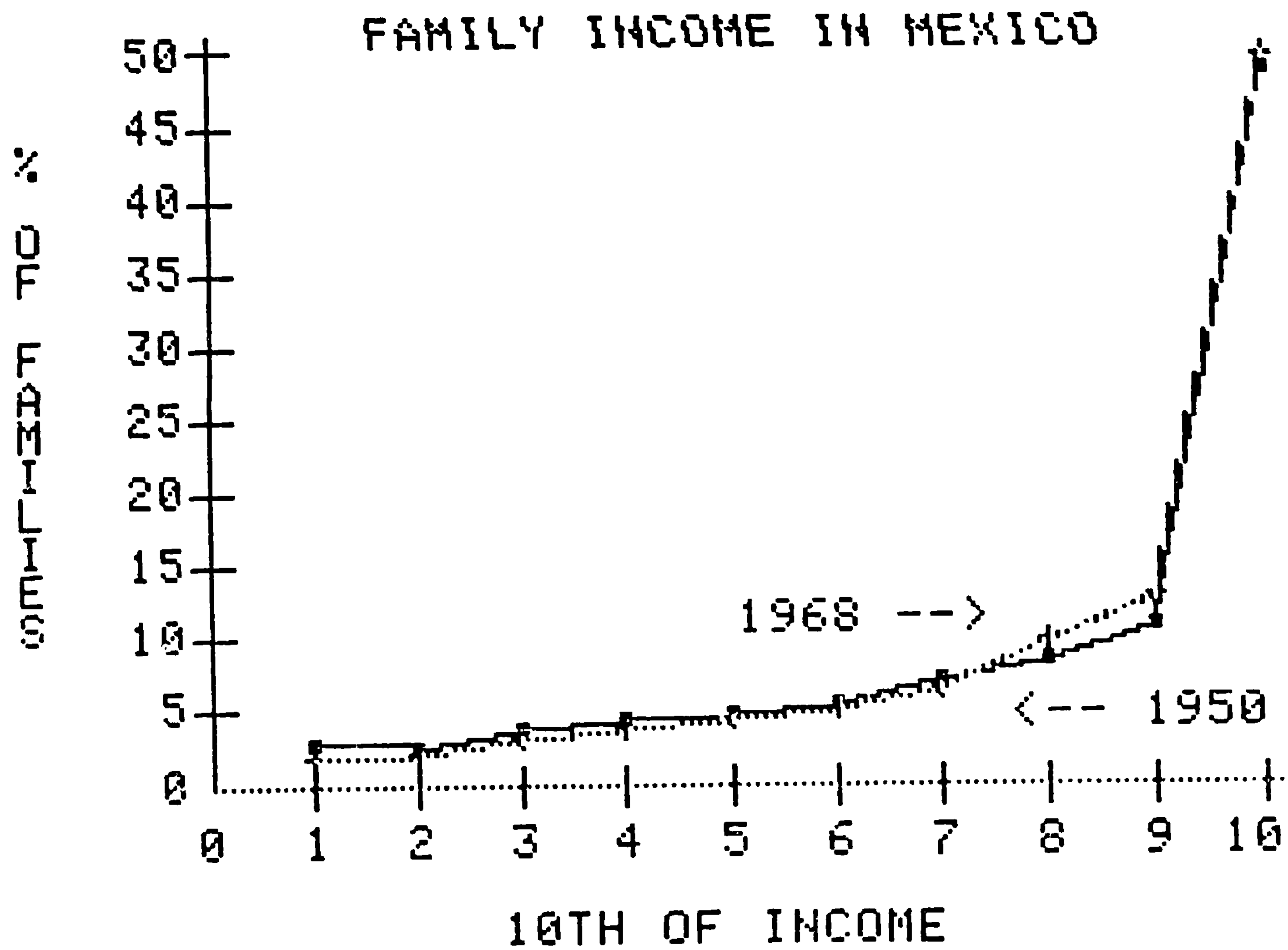

Fig. 2. Non accumulated family income distribution by tenths of total income in Mexico. Source: I. Navarrete in "La economía mexicana. I. Análisis y distribución" (edit. L. Solís). Fondo de Cultura Economica. México. D.F. (1973).

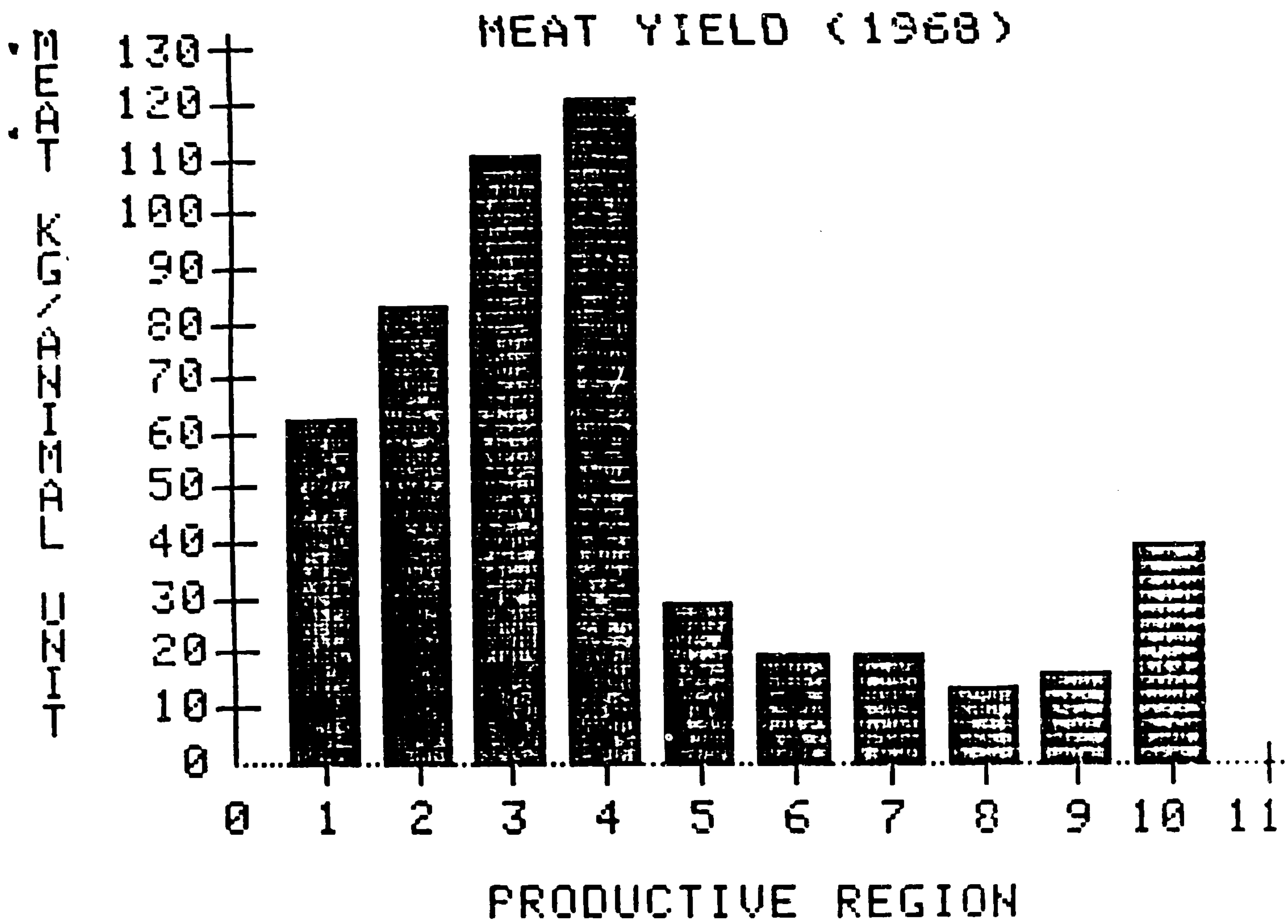

Fig. 3. Productivity of meat in various regions of the World (Kg of meat/animal unit). Each animal unit was taken on the basis of 400 kg of liveweight (WI). Comparisons with swines lambs and goats were made in terms of WI to the 3/4th power. Regions considered were: 1. World 2. USSR. 3. China 4. Europe - USSR. 5. U.S. and Canada. 6. Latin America. 7. Near East. 8. Far East. 9. Africa. 10. Oceania. (Source: P. Jalee. as in Fig. 1).

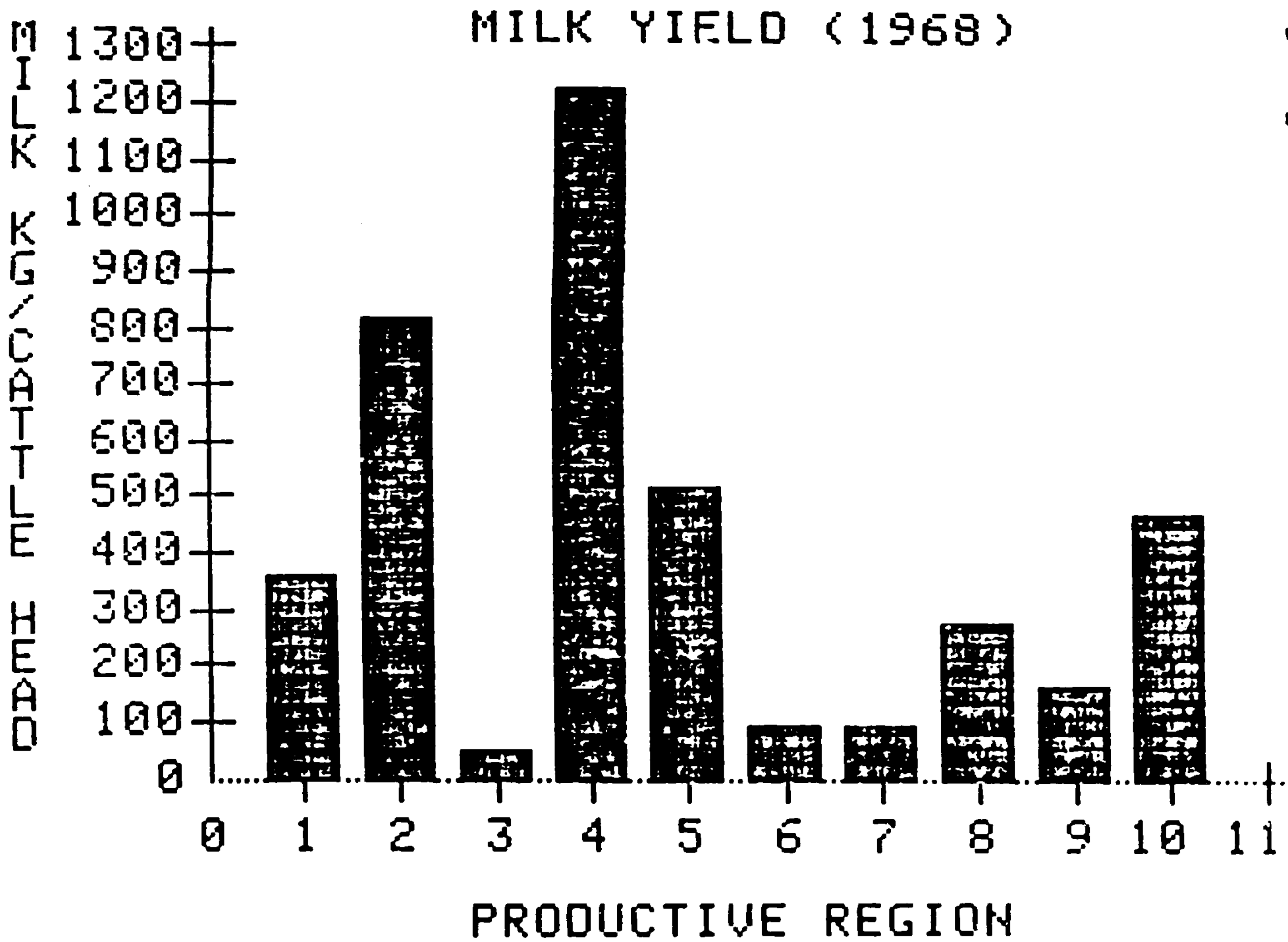

Fig. 4. Productivity of meat in various regions of the World (Kg of meat/animal unit). Each animal unit was taken on the basis of 400 Kg of liveweight (WI) Comparisons with swines lambs and goats were made in terms of Wl to the 3/4th power. Regions considered were: 1. World. 2. USSR. 3. China. 4. Europe - USSR. 5. U.S. and Canada. 6. Latin America. 7. Near East. 8. Far East. 9. Africa. 10. Oceania. (Source: P. Jalee. as in Fig. 1).