BIOTECHNOLOGY IN MEXICO: PROMISES OR THREATS?

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Historical

When the Aztecs were growing the algae *spirulina* for food in the lake of Texcoco or fermenting *aguamiel*, the sweet juice of agave to obtain *pulque*, they would have never imagined the role that fermentation processes would have in the 20th century society. Like almost all civilizations, Mexico has traditional fermented products derived from natural raw materials. These include not only the worldwide known tequila but also some interesting products like *pozol*, a corn based non-alcoholic beverage in which the protein content is increased due to the nitrogen fixation bacteria involved in its fermentation.

It was from *pulque*, that a German microbiologist, Paul Lindner, isolated in 1924 the bacteria known as *Zymomonas molibis*, studied nowadays all over the world because of its high alcohol productivity. However, from the industrial point of view, Mexican biotechnology lost its first battle, when beer produced from barley replaced *pulque*, now considered a second class beverage, and Mexican biotechnology made no significant technological improvements for more than four centuries.

In this article, biotechnology will be reviewed from an historical point of view. In 1857, when Louis Pasteur demonstrated the microbiological nature of the alcoholic process, the fermentation processes could no longer be called "traditional." And in 1944, biotechnology became an industry when industrial amounts of antibiotics were produced due to the huge demand during World War II. By the end of the 1960s, what has been called "actual biotechnology," through fermentation and enzymatic processes was responsible for providing the world with food products, such as cheese, yogurt, bakers yeast, wine and beer, food additives such as glutamate, enzymes, essential aminoacids, vitamins, pharmaceutical products, such as antibiotics, vaccines and hormones, and chemical products, such as ethanol, organic acids and biopolymers.

Biotechnology in 1988 is where electronics was at the end of the 1960s or microcomputers were at the beginning of the 1970s

"New biotechnology" was born this decade with a major technological advance, the so called "DNA technology." It gave new perspectives to biotechnology, not only in industry but also in other strategic fields such as agriculture and health. It has been said that biotechnology is nowadays in the inflection point of the classic technological lifecycle curve, just between the adaptation and the growth phases. The first product of this technology, human insulin, appeared in 1982. It was actually a substitution

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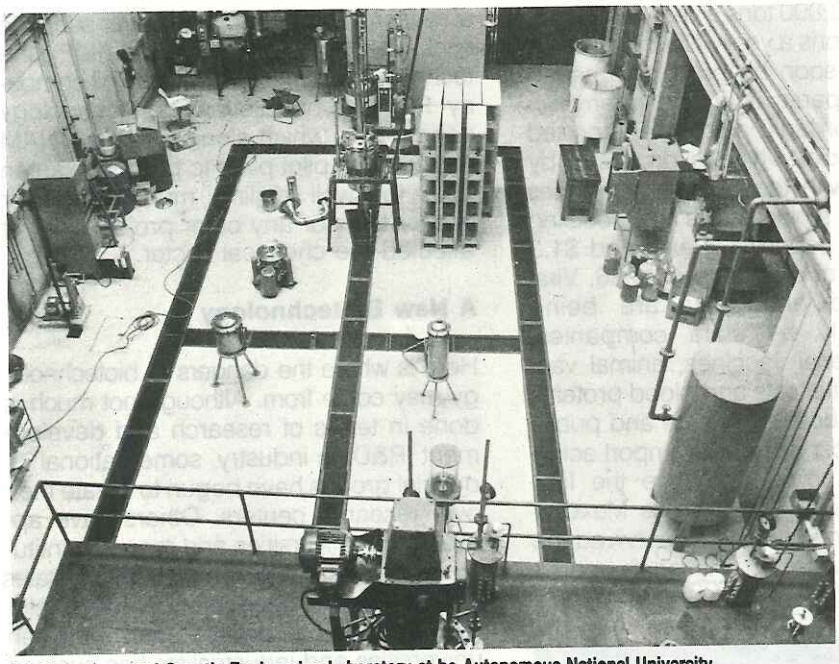


Biotechnology and Genetic Engineering Laboratory at he Autonomous National University.
(Photo from La Gaceta archive)

product because insulin from animal pancreas was available. However in 1987, the U.S. Food and Drug Administration aproved the first new product, tPA (tissue plasminogen activator) from Genentech, a thrombolytic agent. Plants are now being designed and patented with pest-and draught-resistance properties and virus free properties. Micropropagation techniques are employed for germoplasm preservation and plant production. Tissue culture techniques have proven useful for industrial production of several vegetal products such as the shikonine colorant. Biotechnology in 1988 is where electronics was at the end of the 1960s or microcomputers were at the begining of the 1970s. How will this biotechnological boom affect developing countries like Mexico? Is this really, as it has been stated, a departing train in which any country can still get on, or is it like the petrochemical industry in which we arrived late? In this article some aspects of the situation of biotechnology in Mexico are analyzed. I try to present a picture of how the country is facing the hopes and threats that biotechnology represents.

The Mexican Biotechnological Industry

Probably the main bioindustries in Mexico could be included in what has been called "traditional biotechnology." Good quality beer is produced and exported from four main breweries—Modelo, Cuauhtémoc, Moctezuma and Yucateca. More than 70 companies produce wine and brandies. Beer takes 68 percent of the alcoholic

Mexican companies are involved in the manufacture of inocultans for leguminous plants

beverages market, followed by wine and brandies with 19 percent, tequila with 9 percent, and rum 4 with percent. More than 400 companies are involved in dairy products. The average annual growth rate of this sector, however, droped from 6.1 percent in the 1970-1980 period to 2 percent in the 1980-1984 period. Other traditional processes include the production of nearly four tons a month of the algae *spirulina* in the salty waters of the Texcoco lake. It is produced by a parastate company and primarily exported to the United States and Japan. There are approximately 5 private producers of baker's yeast. A French company started operations in this field just a few years ago. Edible mushrooms production had been monopolized for many years by a private company, but in years other producers have appeared in the market. In one of these cases, the technology was developed by a group from the Autonomous National University (UNAM) with the financial support from the National Council for Science and Technology (CONACYT).

Actual Biotechnology

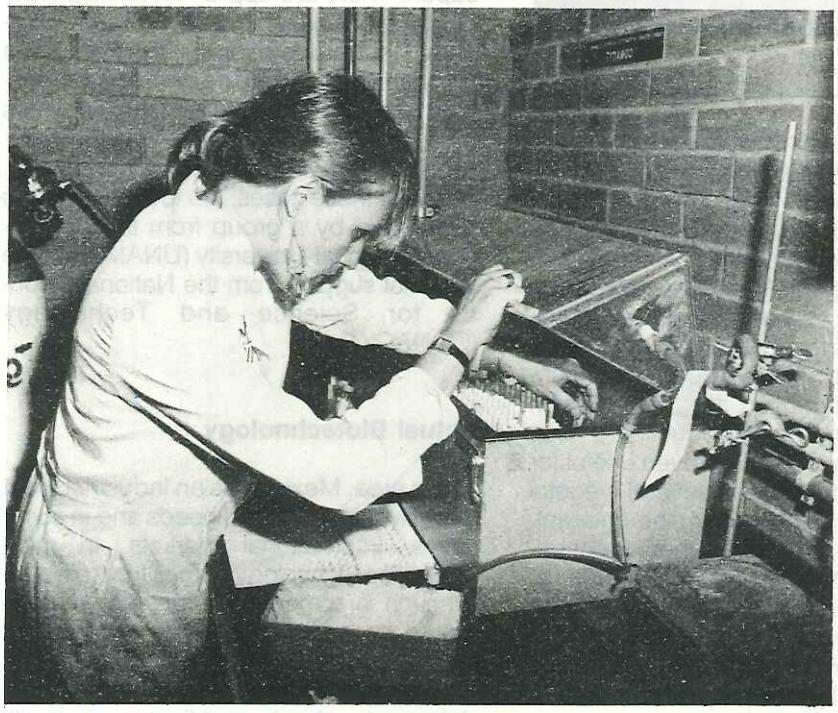
In this area, Mexico has an industrial plant that covers the internal needs and in some cases, international markets. In most cases, the technology comes from abroad, although in some cases, transnational companies such as Pfizer, Miles Laboratories, Bayer and Ciba are directly involved.

Microbial enzymes used in biological detergents, starch modification and milk clotting, are produced mainly by a single plant, with Miles Laboratories technology and participation. Mexico imported enzymes worth a total of $3.13 million dollars in 1987, $.74 million more than in 1986.

Mexican companies are involved, in most cases with Mexican technology, in the manufacture of inoculants for leguminous plants. This 600 ton-a-year market is mainly absorbed by soybean growers. No efficient competitive inoculant has yet to be developed for beans, the basic legume staple in the Mexican diet.

In the pharmaceutical sector, there are nine companies that produce antibiotics and a state company that produces aminoacids by fermentation—6,000 tons a

year of lysine, 3,000 tons a year of glutamic acid and 120 tons a year of leucine. A new company will soon be producing aspartame from aspartic acid and phenylalanine. All the organic acids are imported except citric acid, which is produced by fermentation with technology from Miles Laboratories in a plant that is now doubling its production capacity. It exported $1.3 million dollars of citric acid in 1986. Viral vaccines and antibodies are being produced only by state companies, whereas bacterial vaccines, animal vaccines, diagnostic tests and blood proteins are produced both by private and public enterprises. Most companies import active raw products only to produce the final products in Mexico. There is one Mexican-owned laboratory which has survived the big pharmaceutical transnationals operating in Mexico.



Experiments at below zero. (Photo from La Gaceta archive)

The chemical industry has not been concerned with biotechnology up to now. Because petroleum is abundant, the biological alternatives for solvents—ethanol, methane, glycerol—are not economicaly feasible. There has been interest in using methanol as substrate for single cell protein production but for several reasons, this project has never seen the light. The Mexican Oil Institute (IMP), the technical branch of the national oil company PEMEX, has its own biotechnology department, which along with the UNAM has set up a pilot plant to produce xantan gum for well drilling muds. However neither this nor any other project has yet affected the chemical sector.

The main force of Mexican biotechnology nowadays lies in its human resources

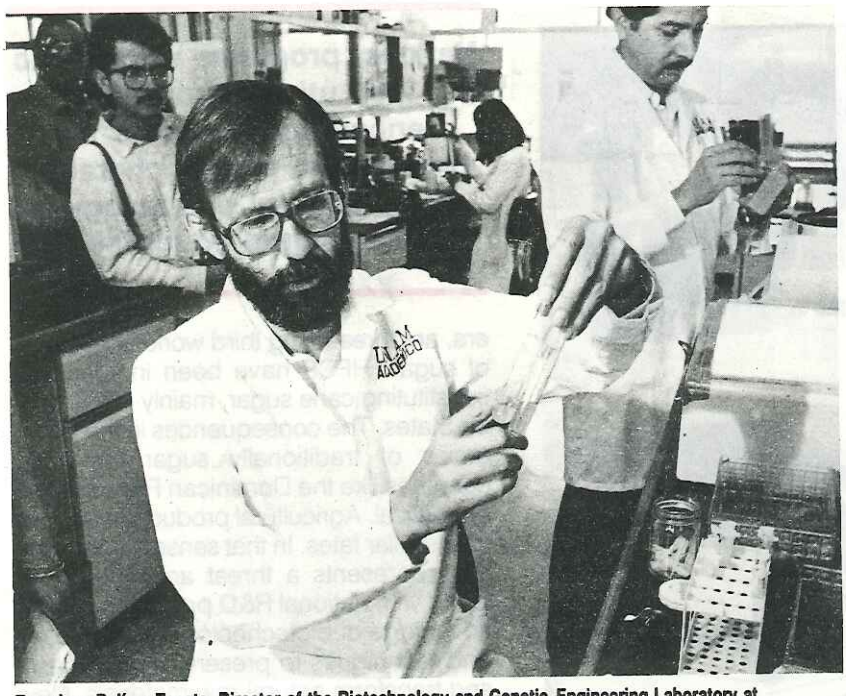
A New Biotechnology

Here is where the dangers of biotechnology may come from. Although not much is done in terms of research and development (R&D) in industry, some national industrial groups have begun to create their own research centers. Others have approached universities and research intitutions. Compare this with the United States where after one decade of DNA technology, the original collaboration between universities and industrialists has evolved into an emerging industry with more than 300 companies. It is difficult to find an important industrial company in the industrialized countries without at least a joint venture program in biotechnology. Dupont, Monsanto, Eastman Kodak, Corning Glass, Ciba Geigy, Bayer, Shell, Pfizer, Upjohn, Nestle, Unilever, Elf, Sanofi, Royal Dutch, and many others, have biotechnology programs. Products have begun to emerge in all areas—new sugars such as alitame and thaumatin; new enzymes such as microbial renin and lysozime; biopesticides; improved plants and seeds; biochips; more than 100 diagnostic tests bases on monoclonal antibodies; DNA probes; new vaccines—Mexico is now importing the hepatitis B surface antigen; hormones—human insulin is now available in Mexico; microbial gums; and new food additives such as colorants and ciclodextrins. There is even biotechnology involved in defense programs.

In this universe of new biotechnology very few companies in Mexico have started micropropagation techniques. And then, only in those agricultural products with sufficient added value: such as is the case of flowers.

Human Resources

Probably the main force of the Mexican biotechnology nowadays lies in its human resources. Excellent scientific groups have been formed during the last 15 years and are now distributed in different centers and universities around the country. They are working in more than 400 projects. Efforts are being made to link them with industrial groups. In a recent document elaborated by G. Arroyo and M. Waiss-



Francisco Bolívar Zapata, Director of the Biotechnology and Genetic Engineering Laboratory at the Autonomous National University. (Photo from La Gaceta archive)

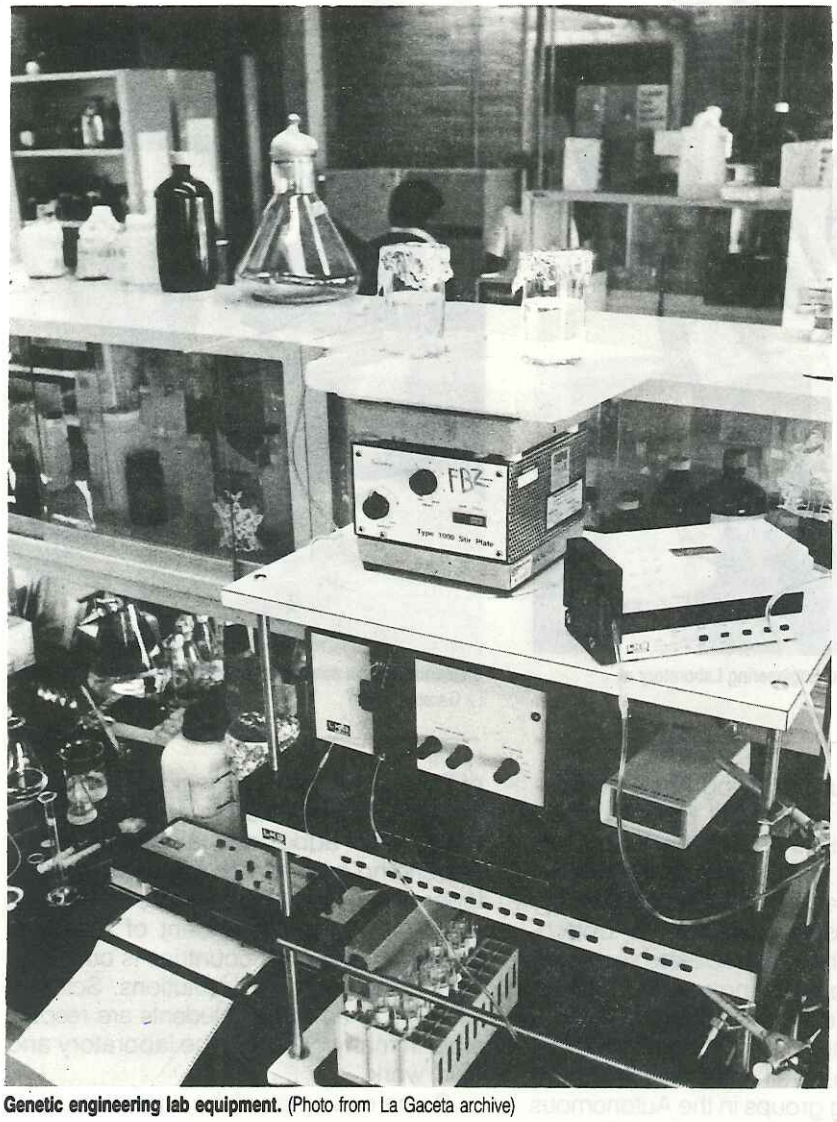
Biotechonology, a science of growing importance. (Photo from La Gaceta archive)

bluth, 36 institutions doing basic and applied research in Vegetal Biotechnology and 24 in Industrial Biotechnology are reported. In an earlier catalog, 116 institutions reported activities in Biotechnology. Institutions exclusively dedicated to biotechnology research have been created such is the case of the Genetic Engineering and Biotechnology Research Center, the Nitrogen Fixation Institute and the Biomedical Research Institute, all at the UNAM. There are other strong groups in the Autonomous Metropolitan University (UAM), the University of Chapingo, the National Polytechnical Institute's (IPN) National School of Biological Sciences and the Mexican Institute of Appropiate Technology.

Biotechnology represents a threat and should be confronted with national R & D programs

Although one large company, such as Novo Industries in Denmark certainly has more scientists than we have in all our biotechnology centers, and although the budget spent in the development of a new single product by the new biotechnology companies is larger than the total annual budget for biotechnology in Mexico, productivity is very high in Mexico because of the low cost of labor. The Mexican government created the National System of Researchers in 1984 which has succesfuly retained scientists in research institutions, with additional tax-free stipends depending on research quality. Research labor, which in many cases constitutes as much as 70 to 80 percent of a project budget in industrial countries is considerably reduced in our institutions. Scientist with Ph.D.s as well as students are responsible in many cases for the laboratory and field work.

Some examples of the type of projects carried out in these institutions are the micropropagation techniques employed not only for flowers and decoration plants, but also in export products like coffee, strawberries, pineapples and in autochthonous industrialized plants such as agave and sisal hemp. The CINVESTAV in Irapuato is probably the strongest in Latin America as far a vegetal biotechnology is concerned. A single cell protein project, produced from molasses is being set up in Mexico City by CINVESTAV. Solid fermentations have been used to propose alternatives for cassava industrialization and other metabolites production. On the other hand, lactic acid fermentation is being studied as a tool for grains and vegetables preservation in the UAM. Enzymatic processes for the extraction of vegetable oils are being in UNAM's chemistry department along with several pilot projects for biological water treatment, with a biodisc system. The same institution is also studying some traditional Mexican fermentation products such as *pozo* and *tesgüino*. Mushrooms production has been taken to



Genetic engineering lab equipment. (Photo from La Gaceta archive)

industrial level. Milk substitutes and fermentation of agricultural wastes are being used as alternatives for cattle feed in the UNAM's Biomedical Research Institute. Proteolytic enzimes from Mexican fruits and vegetables have been extracted, identified and studied at the IPN. These projects are mentioned to give an idea of the situation but by no means is this list intended to be a complete review of institutions and project.

Hopes or threats?

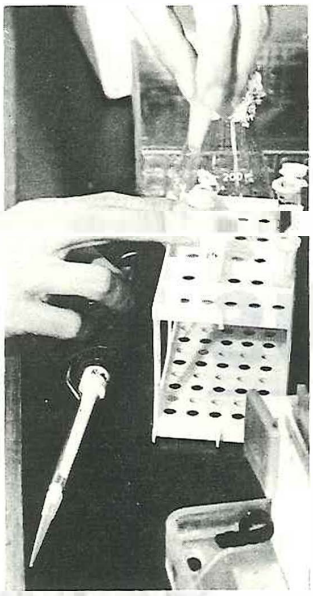
There is an increasing impact of biotechnology in the production of food and agricultural products, as more food and more higher quality food will be available and controlled by major transnational companies.

A second battle is being lost. High fructose corn syrups (HFCS), produced by an enzymatic process from corn starch in a technology developed before the DNA era, are threatening third world production of sugar. HFCS have been increasingly substituting cane sugar, mainly in the United States. The consequences in the economies of traditionally sugar exporting countries like the Dominican Republic are dramatical. Agricultural products in general face similar fates. In that sense, biotechnology represents a threat and should be faced with national R&D programs, taking advantage of biotechnological processes and techniques to preserve germoplasm and transform natural raw materials. New alternatives for the transformation of our natural products must be developed in many cases with the help of biotechnology.

National programs with public institutions should be encouraged in order to balance the private character of agricultural technology in developed countries

First of all, priorities should be defined. There have been several reports dealing with the diagnosis of the situation of biotechnology in Mexico. However, we still lack a national plan. There is no "Mexican Project." Coordination is difficult even in the institutions themselves. Research is being done in almost all areas of biotechnology without basic guidelines. The Brazilians have their alcohol program. Japan is trying to convince developed countries to enter into the Human Frontiers Program. In the United States, coordinated action is taken place around the human genome. The Cubans have their interferon project. We have seen cassava production programs born and die, for reasons which do not include the lack of scientific and technical support and interest. Amaranthus, a protein rich grain known by the Aztecs, was rediscovered abroad.

National programs between public institutions and national groups or international organizations interested in joint programs for underdeveloped countries should be encouraged in order to balance the private character that agricultural technological advances is taking in developed countries. The "Latinamerican Biotechnology Network" or the UNIDO's Regional Biotechnology Program are examples of this type of actions. There has been special finantial support from CONACYT in order to consolidate national postgraduate programs resulting in the strengthening of the seven institutions that offer masters and doctorate degress in biotechnology.



Biotechonology experiments.
(Photo from La Gaceta archive)

Investment should support basic as well as applied research. In the haste for industrial development, one tends to forget that today's basic research is tomorrow's applied research. As has been stated by a distinguished Mexican researcher, Dr. Ruy Pérez Tamayo: "There are only two types of research, good research and bad research." Financial institutions and industrial groups from the public and private sectors should look for both investment oportunities of immediate application and long-term investment in basic research.

There is an increasing interest from transnational companies in investing in research in Mexican institutions. During these times of economical crisis this provides a source of economical revenues and scientific prestige. However there is the grave danger of deviating research toward models far away from our basic needs and economic reality.

Finally, a word about industrial patents property. In the United States, DNA technology opened in 1980 the way for industrial protection of genetically modified microorganisms which five years later was extended to all types of genetically modified plants. Since last year, new multicellular organisms can also be patented: animals will soon be patented! There is nowadays a real patent war in the United State involving universities and private companies. In Mexico, the deadline is 1997. After this date all type of biotechnological and genetic processes could be patented: strong pressure is being made so that Mexico accepts patents on plants and animals.

Will biotechnology be used for development and self-sufficient food supply or for more economic dependence? □

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