
BIOTECHNOLOGY: INDIA SCENARIO AND WORLD SCENARIO – IN LAST 20 YEARS

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Traditional pharmaceutical industries are now diversifying into biotechnology. Some companies are showing interest in bringing recombinant and transgenic products into the Indian market. As per the available data, about 31 companies with investment of Rs. 28500 million and turnover of Rs. 2650 million produced diverse vaccines that include tuberculosis, measles, diphtheria, pertussis, tetanus and polio. . Exports are mainly to Europe, Japan and the USA. The total turnover of the industry in 1997 was around Rs. 820 million including exports of around Rs. 600 million. India imports about 70 percent of the total enzyme consumption, majority for detergents, textiles, starch and pharmaceutical industries. Novo Nordisk and Genencor have significant percent in India.

INTRODUCTIONS WITH RESULTS AND CONCLUSIONS

As per the data available, the investment in biotech industry in India in 1997 was at about Rs. 55 billion (US 1\$ 1.3 billion), distributed among 800 companies (Table III). This does not include investment in conventional hybrid seed industry, aquaculture and in biological waste treatments.

Most of these companies are engaged in production of controversial low-tech products like alcohol, bio-fertilizers, bio-pesticides, mushrooms, floriculture, etc. of late, in order to keep pace with the global trend, some Indian companies have started paying attention to development of high-tech bio-tech products. Traditional pharmaceutical industries are now diversifying into biotechnology. Some companies are showing interest in bringing recombinant and transgenic products into the Indian market. Two companies have started manufacturing recombinant Hyderabad, uses an indigenously developed technology.

It could be observed from the below table that the turnover of biotech industry in 1997 was about Rs. 47,000 million. The medical biotech sector contributes about 48 percent of the total, followed by the industrial and the agriculture sectors at 44 percent and 6 percent, respectively.

Table 1 Indian biotech Industry-Summery¹ (Rs. Million)

Sector/ Sub-sector	No. of Companies	Investment	Turnover
I. Medical			
Vaccines	31	2850	2650
Diagnostics	110	1000	3600
Antibiotics	13	14000	14000
r-DNA Products	8	360	2370
Sub-total	162	18210	22620
II. Agriculture			
Tissue culture	30	1000	200
Biofertilizer	70	150	230
Biopesticides	50	500	400
Floriculture	135	1850	820
Transgenic crops	3	1120	0
Mushroom	23	3500	1800
Sub-total	311	8120	3450
III. Industrial			
Alcohol	280	28000	19500
Enzymes	17	250	595
Organic acids & other products	15	400	750
Sub-total	312	28650	20845
IV. Environmental	15	NA	NA
Grand Total	800	54980	46915

Table 2 Current Consumption and Anticipated Future Demand of Biotech Products in India

-	Consumption (Rs. in crores)	Consumption (Rs. in crores)	Consumption (Rs. in crores)
PRODUCT CATEGORY	1991	1995	2000 A.D
[1] Human and animal health products	333	515	1030
[2] Agricultural biotech products	44	187	580
[3] Industrial products	138	240	475
[4] Forest biotechnology	-	10	50
[5] Effluent treatment	-	10	50
[6] Composting, vermiculture	-	5	10
[7] Microbial leaching, biobenification	-	-	10
[8] Others (oligonucleotides, plastics etc.)	2	5	10
TOTAL	517	972	2215

Source: www.biotechsupportindia.com

1. Health Care:

In the health care sector, investments have been the highest in antibiotics, to the tune of Rs. 14000 million, (which is about 25 percent of the total investment in the biotech sector), followed by vaccine. The government's share of investment is estimated at about 50 percent. In the recombinant therapeutic products sector, investment has been very low so far, about 2 percent of the total investment in the biotech sector. A brief analysis about some sub-sectors is given as follows.

Vaccine and Blood Products:

As per the available data, about 31 companies with investment of Rs. 28500 million and turnover of Rs. 2650 million produced diverse vaccines that include tuberculosis, measles, diphtheria, pertussis, tetanus and polio. A part from these, indigenous production has also been recently established for typhoid, Japanese encephalitis, rabies and recombinant hepatitis B vaccine. All these vaccines are used against many bacteria and viral diseases under the National Immunization Programme gives the products of vaccines in the country.

The blood products made in the country include blood plasma, gamma globulin and antisera for tetanus, diphtheria and rabies.

Diagnostics:

At present, the diagnostics sub-sector is the second largest in the medical biotech area and third largest among the whole of biotech industry. The diagnostic kits marketed in India are mainly those imported in bulk and repacked. As in 1997, this sub-sector had 110 companies with an investment of Rs. 1000 million and turnover of Rs. 3600 million.

Antibiotics:

In the health care area, antibiotics occupy the largest position with investment and turnover of Rs. 14000 million each in 1997. India is well advanced in the production of antibiotics. The processes used are based on fermentation. Thirteen out of the thirty antibiotics consumed in the country are produced indigenously (Table IV).

Table 3 Antibiotics Production in India²:

Sr. No.	Unit	Antibiotics Produced
1.	Hindustan antibiotics, Pune	Penicillin G
2.	Torrent Gujarat Biotech, Ahmedabad	Penicillin G
3.	SPIC Pharmaceuticals, Cuddalore	Penicillin G
4.	JK Pharmaceuticals, Cuddalore	Penicillin G
5.	Alembic Chemical Works, Baroda	Erythromycin, tetracycline
6.	Synbiotics, Baroda	Streptokine, tetracycline
7.	Pfizer India, Mumbai	Oxytetracycline, amphotericin
8.	Glaxo India, Mumbai	Greosolin
9.	Lupin Laboratories, Mumbai	Rifampicin

Recombinant DNA (r-DNA) Products:

So far, production has been established of one recombinant DNA therapeutic product only, namely, Hepatitis B vaccines by Shantha Biotechnica and Bharat Biotech, both at Hyderabad. A few other recombinant therapeutic products are imported. This particular industry is now a fast growing industry. As in 1997, this sub-sector had an investment of Rs. 360 million, which a turnover of Rs. 2370 million.

2. Agriculture Biotech:

Agriculture biotechnology activities are not capital-intensive. According, the agro-biotech sector has been the lowest contributor, of which the mushroom industry accounts for about 52 percent followed by floriculture. Both these sub-sectors earn foreign exchange. In this sector, mushroom production attached the maximum investment of Rs. 3500 million (43 percent), followed by floriculture at Rs. 1850 million (23 percent). Most of the mushroom and floriculture units have been set up as 100 percent export oriented units (9EOUs). A brief analysis of some important sub-sectors is given below.

Tissue Culture:

Protocols for tissue culture of various forest trees, and agronomical and ornamental species have been developed in research laboratories and universities. Tata Energy Research Institute (TERI), New Delhi and National Chemical Laboratory (NCL), Pune, have set up two micro-propagation technology parks (MTPs) under sponsorship of DBT to develop and transfer tissue culture protocols and to provide related consultancy and training.

Floriculture:

There are over one hundred and thirty approved floriculture units for export, centered mainly on Delhi in the North, Bangalore in the South and Pune in the West. The range includes rose, carnation, chrysanthemum, gladioli, anthurium and gerbera. Aster and orchids are likely to assume significance in the coming years. Exports are mainly to Europe, Japan and the USA. The total turnover of the industry in 1997 was around Rs. 820 million including exports of around Rs. 600 million. At the same time, there are inputs from imports of plant stock to the tune of Rs. 200 million. Most of the export-oriented units have technical collaborations with companies, such as, Flodac, Dalsem and Stockman Rozen. Several agricultural universities are carrying out research related to floriculture, though not generally oriented towards commercial application.

Biopesticides:

There are about fifty units producing engaged in the production of biofertilizers, such as, rhizobium, azotobacter, acetobacter, azospirillum, azolla, blue green algae, phosphate solubilising bacteria and mycorrhiza using indigenous technology. The total annual production in 1996-97 has been around 6500 TPA against an installed capacity of about 12600 TPA. DDT and Endosulfan are example of such pesticides. Now a day they are banned in certain countries.

(Meenakshi et al. 2012; Zitko 2003). The wide applications of organochlorine (OC) pesticide such as these pesticides are employed for plant protection against insect pests (Harish. R et al.2013).

Hybrid Seeds:

There are twelve major units engaged in hybrid seeds production. R7D projects based on plant molecular biology of wheat, rapeseed, mustard, chickpea and other crops are also in progress with a view to evolving seeds for plants having desirable traits like high productivity, tolerance to various biotic and biotic stresses such as, climatic conditions, salinity and drought. New hybrids of rice, millets, sorghum, cotton, sugarcane, oats, mango, banana, guava, vegetables and fruits have already been developed and released.

Mushrooms:

There are 14 major mushroom producing units that are export-oriented, with a capacity of 39000 TPA and a production of 30000 TPA.

Transgenic Crops:

Transgenic crops offer great potential for increased productivity, pest management and as bioreactors for the production of the therapeutic and other commercially valuable products. A number of research projects under way.

3. Industrial Biotech:

In the industrial biotechnology sector, alcohol accounts for 98 percent of the investment. In fact, this sub sector contributes about 93 percent of the industrial sector's turnover, 42 percent of the total biotech industry's turnover and 51 percent of the total investment in the biotech sector. Alcohol industry and the antibiotics industry together contribute about 71 percent of the total biotech business. A brief analysis of some segments of industrial biotech products is given as follows.

Alcohol Production:

Most distilleries in India employ batch fermentation of molasses using the yeast *Saccharomyces Cerevisia*. In the last decade, there has been a shift from batch to continuous fermentation. Efforts have been directed towards developing yeast strains having high osmo tolerance and using immobilized enzymes, both of which are capable of enhancing productivity. The focus areas in R&D have been strain improvement, continuous process, energy saving and use of alternate raw materials. National Chemical Laboratory (NCL), Pune; Institute of Microbial Technology (IMTECH), Chandigarh; Indian Institute of Technology (IIT), Delhi and Vittal Mallaya Scientific Research Foundation (VMSRF), Bangalore are some of the institutes engaged in research in these areas.

Enzymes:

Development and application of modern enzymes are in a stage of infancy in the country. In the field of enzyme immobilization, penicillin amylase for 6-APA manufacture is the only technology that has been developed for industrial scale application. Enzymes are now being used in diagnostics, bio-sensors and medical research. The Indian market during 1997-98 for enzymes is estimated at Rs. 800 million. The major markets are today in Textile, Detergent, Leather, Pharmaceuticals and Dairy Industry.

- i. **Enzyme usage in textile sector:** This can be classified into main five areas viz, resizing, bio-polishing, bio-washing, bleach clean up and fiber modification. Indian's per capita consumption of denim is far behind most of the other countries in the world and this offers tremendous scope for growth. Most of the major branded jeans companies in the world have established their presence in India. As for denim 'Jeans' processing, enzymes are key material. India textile enzymes market is expected to grow considerably. The market share of textile enzymes in terms of value is expected to increase by 25 percent next year.
- ii. **Enzyme usage in leather sector:** usage of enzymes in leather segment is also anticipated to grow considerably in volume terms. India is today the fourth largest leather producer in the world and with environmental regulations becoming increasingly stringent, Indian tanneries will be forced to use more and more enzymes partly replacing currently used chemicals for tanning, re-tanning, dyeing, etc. as far as possible. This is expected to result in a significant reduction in the volume of harmful effluents generated, and the cost of the treatment and disposal.
- iii. **Enzyme usage in detergent sector:** Detergent and animal feed are two other major sectors where the usage of enzymes is expected to grow rapidly in the near future. Detergent enzymes have the largest market of Rs. 14 crore and accounts for nearly 33 percent of the total market. Household laundry, household dish-washing and industrial laundry are the three segments of the market for enzyme-based detergents. However, in India, enzymes are mainly used for household laundries. Proteases, amylases, lipases and celluloses are the main enzymes used here. Currently, very few companies like Procter and Gamble (Ariel), Hindustan Lever (Surf) and Henkel (Henko) are using detergent enzymes but lots of other small detergent enzyme market is expected to grow very soon.
- iv. **Enzyme usage in starch, food and beverages industries:** this can be classified into three main areas.
 - Enzymes modifying carbohydrates like starch, sucrose, glucose, fructose, etc.
 - Enzymes modifying proteins, like rennet's used in manufacturing of cheese and proteases used in tenderization of meat or production of protein hydrolysates.
 - Enzymes modifying lipids for hydrolysis of oils and fats to give monoglycerides, diglycerides and free fatty acids.

Starch conversion would be the major application of enzymes. The major enzymes used in this sector are alpha amylase, glucoamylase and glucose isomerases. Starch hydrolysis has gradually become a wholly enzymatic one in the last couple of years, and arranges

of starch degrading enzymes are now available in sufficient quantities at competitive rates. Growth of this sector is related to the growth is demand for high-fructose corn syrup used by the soft drink industry. Soft drinks are yet very little explored in third world countries by major soft drinks manufactures and this could enhance the demand for enzymes.

Enzyme market for beverages is also likely to grow very fast. Pectinase are the most important enzymes used in juice and wine production. Beta Glucanases find very large application in beer brewing. Increased demand for the production of low calorie beers would drive the growth of enzyme market in this segment.

The growth of basket confectionery segment has been very high in India. Fungal alpha amylase, protease and Hemicellulase enzymes are widely used in the baking sector for bread and biscuit manufacturing. Output of bread in 1995-96 was 14 lakh tones, which was a phenomenal 40 percent increase over the previous year. Enzymes were used in baked products resulting in a steep increase in market food enzymes in this sector.

- v. **Animal feed:** enzymes are relatively a new class of animal feed additive. Their function is to act as catalysts to enable more efficient utilization of the animal feeds. They act as bio-catalysis and assist in digestion process for the total utilization of nutrients and minerals, which are excreted unused. Solid state fermentation of agricultural wastes into rich products as well as conversion of such waste into pro-biotic for enriching poultry and animal feed are also picking up fast.
- vi. **Dairy:** Milk coagulating enzymes have dominant market in this sector. India is the largest manufacturer of milk in the world. In recent years, microbial rennates and recombinant chumisin have very good market for cheese making from milk. The byproduct of cheese manufacturing process (whey) can be enzymatic ally converted into glucose and galactose; they also have an application as a sweetener.
- vii. **Chemical synthesis:** There are a number of chemicals like acryl amide, vitamin C, monosodium glutamate, gluconic acid, lactic acid and L-malic acid produced today by the bio-transformation using enzymes. Even the conversion of glucose to fructose, penicillin-G to 6-APA, glycerides for emulsifiers, is a major application of industrial enzymes.
- viii. **Pulp & Paper:** There is a worldwide demand to replace chlorine used for bleaching in the pulp and paper industries due to environmental pressures. Enzymes like xylanase can be used in large quantities in this industry. Enzymes also can be used for lignin removal, paper coating, pitch removal and adhesive preparations.
- ix. **Waste water treatment:** Effluents emanating from industries, such as, chemical, textile, paper and pulp, food processing and distilleries, if let out untreated, pose serious environmental problems. There is great potential for the development of consortia of micro-organisms and methods of their use for treating the complex effluents to acceptable standards. These effluents have a variety of unusual chemicals including a range of aromatic hydrocarbons and their derivatives (De Vos,1992).

- x. **Solid waste treatment:** conversion of solid municipal wastes and agricultural residues into organic fertilizers has been achieved commercially by a technology developed by Excel Industries, Mumbai. Developments of pilot and demonstration plants for biomethylation of organic wastes are progress at various centers.
- xi. **Bioremediation:** Retrieving land and water sources from the adverse impact of contamination by oil spills, heavy metals, etc. by the use of micro-organisms is an area that will assume significant is oil exploration and refining, mining and metallurgy.

4. Consumption of Biotech Products:

The consumption of the biotech products is growing rapidly in India. As observed from Table V, the consumption growth rate increased from about CAGR of 13 percent during 1992-95 to a CAGR of about 41 percent during the next two-year period of 1995-97. Of the total consumption of Rs. 53670 million in 1997, 72 percent was met by domestic production and the balance 28 percent by imports.

Table 4 Consumption Trends in Indian Biotech Industry³:

(Rs. Million)

	1992	1995	1997
Healthcare	13750	19590	26370
Agriculture	680	1540	2400
Industrial	4290	5700	24470
Others	20	300	430
Total	18740	27130	53670

The human and animal health care products dominate current biotech products consumption. Out of the total consumption of Rs. 26370 million, nearly 70 percent was based on local production and 30 percent imports. No r-DNA product was locally produced until 1997. However, recombinant therapeutic proteins worth of Rs. 2370 million were imported and used. In 1997-98, an indigenous Hepatitis B vaccine worth Rs. 70 million was sold, the sale increasing by almost 300 percent to Rs. 270 million in 1998-99.

In the agriculture sector, floriculture is responsible for a large part of the current consumption followed by biofertilizers, biopesticides and mushroom.

In industrial biotech products, industrial alcohol accounted for Rs. 19500 million. In case of enzymes, the total consumption of industrial enzymes in India in 1998 is about Rs. 800 million. The different segments are given in Table VI.

India imports about 70 percent of the total enzyme consumption, majority for detergents, textiles, starch and pharmaceutical industries. Novo Nordisk and Genencor have significant percent in India. There are very few real manufacturers of enzymes in India and their collective share is about 30 percent.

Among organic acids, lactic acid market was Rs. 16 million. Lactic acid and its derivatives have a wide range of applications in food processing and pharmaceutical industries.

Table 5 Total Consumption of Industrial Enzymes in India in Different Segments⁴:

Consumption Sector	Year1998		Expected value by year 2000-01 in million rupees
	% Marker share	Value in million rupees	
Textile	25	200	240
Leather	8	64	90
Pharmaceuticals	19	150	195
Animal feed	7	50	65
Detergents	12	90	120
Starch, food and beverages	9	72	90
Exports	8	60	130
Research and Diagnostics	6	50	70
Others	8	64	1200
Total		800	1200

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