APPLICATIONS OF BIOTECHNOLOGY IN INDUSTRIES: IMPLICATION FOR NATIONAL DEVELOPMENT

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Abstract
The possibility of the use of microbes as a replacement for the conventional industrial processes in the production of goods and services has given rise to a field of study called Bio-Technology. Bio-Technology focuses on the applications of living organisms, biological systems and processes in manufacturing and services in industries. This paper examined the various applications of biotechnology in production of bio-fuels such as ethanol and biogas, mining, waste management, agriculture and medicine. In spite of the question of ethics and safety raised by critics, biotechnology has the potential to solve the problem of unemployment, high energy cost, pollution and food shortage. In order for Nigeria to take advantage of the benefits of biotechnology the paper recommended the establishment of biotechnology research centres in all tertiary institutions. The proper funding of the National Biotechnology Development Agency, the organization of seminars and workshops and the drawing up of appropriate legislature to guide research in biotechnology.

Ever since man discovered the role of yeast, a living organism, in the fermentation of sugars to produce alcohol, scientists have continued to search for other uses of microbes in the production of goods and services. This has given rise to a field of study called Bio-Technology which is becoming a multimillion naira industry.

According to Taylor, Green, Stout and Soper (2003), Biotechnology is the application of living organisms, biological systems and biological processes in manufacturing and servicing industries. Advances in biotechnology have led to the development of various techniques in order to improve microorganisms, plants and animals. These techniques include genetic engineering and cloning. Genetic engineering is a technique in molecular biology that involve manipulation of the hereditary material called genes in living organisms to create new features and abilities in the organisms. This technique is also called Recombinant DNA Technology. Cloning on the other hand, is the making of identical copies of a molecule or organism. Biotechnology provides both products and services for the benefit of man (Tamarin, 1999).
Microorganisms are becoming important tools for industrial processes. This is possible because biotechnologists have continued to surmount the challenges posed by the movement from the small laboratory environment to large scale industrial production.

Microorganisms are very useful and suitable for industrial processes because of the following reasons.

i. They have very simple genetic structure that can easily be manipulated to assume new abilities and forms.

ii. They have simple nutritional needs that are easily met.

iii. They can be produced in large numbers because they have high growth and multiplication rates which can easily be controlled.

iv. The ability to multiply and grow fast result in higher yields and specificity of product than conventional processes.

v. They have the ability to produce certain complex chemicals such as hormones and antibiotics which are difficult to produce through other conventional industrial means.

vi. They are active at lower temperature than conventional industrial procedures leading to savings in cost of energy, (Taylor, et al., 2003).

Fig. 1: Applications of Biotechnology (Taylor, et al., 2003)
The following industries can be driven by biotechnology.

i. **Food and Drink**

The first application of biotechnology was in the food and drink industry. Even though the making of bread, cheese, yoghurt, vinegar and alcoholic drinks such as beer and wine dates back to thousands of years, it was Louis Pasteur in the nineteenth century who first showed that fermentation was due to the activity of microorganisms. This necessitated the need for large scale industrial production of yeast and other microorganisms. Biotechnologists have designed and built bioreactors or fermenters which are chambers in which microorganisms are cultured in a liquid or solid medium. Fermentation takes place in the bioreactors and the desired products are either the cells e.g. yeast (biomass) or some enzymes, drugs, alcohol etc. The fermentation of milk produces several diary products which include cheese, butter, yoghurt, sour cream etc.

A new source of food is the Single Cell Protein (SCP). It is protein obtained from large scale growth of microorganisms such as bacteria, yeasts and other fungi and algae. SCP is also a useful source of minerals, vitamins, fats and carbohydrates for human and animal consumption. The advantage of using microorganisms as source of food includes their ability to grow rapidly and occupy less space than conventional crops and animals. They can survive and grow on a wide range of wastes land not suitable for agriculture and are independent of climatic conditions. They are more easily modified genetically and their protein content are relatively high. Examples of SCP products are pruteen and mycoprotein. Yeast cells are also rich in vitamins and can be made into vitamin-rich tablets (Mader, 2001).

ii. **Biofuels**

The recent increase in the price of petroleum products have pushed many nations to embark on a desperate search for alternative sources of fuel. The search has focused on using living organisms and biological processes as sources of fuel especially ethanol and biogas (Garba and Mangset, 2006).

(a) **Ethanol** – Since 1975, Brazil has successfully produced and used ethanol as fuel using sugarcane as the raw material. Some Brazilian cars are adapted to run on pure alcohol. Over 11 billion litres of ethanol was produced in Brazil in 1985. Other crops used in the production of Bio-fuels include jatropha, grains such as maize, cassava and sorghum (Cunningham, 1996).

On February 24, 2008 the first ethanol powered airplane belonging to Virgin Atlantic flew from London to Amsterdam on a 20 percent bio-fuels. Ethanol is used to power the agricultural spraying aircraft in Brazil. A flight using bio-fuel produced from Jatropha was scheduled for the 4th quarter of 2008 by Air New Zealand. Vegetable oil, palm oil, castor oil and soybean oil are being used for Biodiesel. (Bamikole, 2008).
(b) **Biogas** – Researches have also been carried out on the production of biogas from the fermentation of waste materials by bacteria and other microbes. Biogas is about 50 – 70% methane with traces of nitrogen, hydrogen, and other gases. Natural gas is about 80% methane. The waste materials usually used include, animal manure, sewage sludge, domestic waste, food waste, paper wastes and plant wastes. Water hyacinth, a plant that causes blockages of waterways have been fermented to produce biogas in the US, India and China. Small scale digesters are being used to produce biogas for local use in India (Taylor *et al.*, 2003).

iii. **Microbiological Mining**

Microorganisms are becoming important tools in the extraction of metals from their ores. This process is called biotechnology. Bacterial leaching is used throughout the world as an additional technique of extracting metals from ores (mainly copper and uranium). More than 10% of the copper extracted in the USA in 1983 worth over 300 million dollars was through bioleaching. The bacteria convert insoluble metal to soluble metal compounds from which the metal can easily be extracted.

Bacterial leaching is less expensive compared to conventional mining methods which can only be used for ores that are rich in the metal and commercially viable. But low grade ores can be exploited commercially using bacterial leaching.

Another advantage of bioleaching is that the cost, danger and environmental damages associated with conventional deep mining is avoided. The leaching solution is pumped into the ground to dissolve the metal. The solution containing the metal is the pumped out and the metal easily extracted. The damage to land and the wastes created by digging and excavation is prevented (Gottfried, 1993).

iv. **Medicine**

The traditional medical products of biotechnology were antibiotics. Advances in biotechnology especially in genetic engineering have led to the production of new drugs. One typical example is human insulin, the hormone responsible for regulation of blood sugar. Inability to produce this hormone causes the disease called diabetes which is controlled by taking insulin injection. Traditionally, insulin was extracted from the pancreas of cows and pigs, but this differs from human insulin and some patients have allergic reactions to the insulin from cow and pig. Biotechnologists solved this problem by genetically engineering bacteria to produce the human insulin. This was done by inserting the human gene that produces human insulin into the genome of bacteria. The human gene directs the bacteria to produce human insulin. Human insulin produced by the bacterium *Escherichia coli* was first marketed in Canada in 1983 (Lodish, 1995).
Another example of the application of genetic engineering is in the treatment of dwarfism caused by very low level of human growth hormone in children. Because the growth hormone of different animals works only in the species of origin, the treatment of dwarfism relied on growth hormone extracted from the pituitary glands of dead humans. This problem was however solved when the human gene for the hormone was inserted into a bacterium which acquired the ability to produce the hormone in large quantity. The hormone Bovine Somatotrophin (BST) which is similar to the human growth hormone (HGT) has been produced using the same method.

According to McFadden and Keeton (1995), one major area where genetic engineering is making progress is gene therapy. This will bring relief to all the sufferers of genetic hereditary diseases such as sickle cell anemia, for which there was no known cure. Gene therapy is simple replacing the genes causing the disease condition with a normal gene.

v. **Waste and Oil Spillage Management**

Micro-organisms have come to the rescue of man in clearing up the wastes generated by his activities. Waste materials such as sewage, domestic wastes, food wastes, paper wastes, spoilt crops etc are becoming raw material for bacteria and yeast for the production of biogas and ethanol respectively as biofuels.

The ecological damage caused to the environment especially aquatic life by oil spillage is a major issue and area of conflict between oil bearing communities and exploration companies. Present methods of cleaning oil spillages through physical barriers are yielding little result. Biotechnologists are attempting to produce genetically engineered bacteria capable of cleaning up oil spills. When sprayed on surfaces polluted by oil, the bacteria is capable of breaking down the four main groups of hydrocarbon present in the oil into harmless soluble compounds (Lodish, Baltimore, Berk, Zipurskey, Darnel and Matsudiara, 1995).

vi. **Biological Detergent**

Enzymes which are biological catalysts found in living cells are being used as washing powders. They have the ability of removing stains of biological origin. Examples of such enzymes are proteases which remove stains of protein origin, amylases remove starch stain and lipases digest fat, oil and grease stains. The first successful biological washing powders were introduced in the 1960s (Taylor et al, 2003).

vii. **Agriculture**

One major area where biotechnology especially genetic engineering has found useful application is agriculture. This has led to the production of
genetically modified (GM) food and reduction in cost of farming activities through the following processes.

i. **Bio-fortification of Cassava:** Richard Sayre, a professor of plant cellular and molecular biology at Ohio State University while presenting an update on the Bio-cassava plus project on June 30, 2008 at the American Society of Plant Biologists meeting in Merida, Mexico reported an ambitious genetic engineering work on cassava. This work is important because cassava is a primary source of energy, and staple food for an estimated 800 million people worldwide including 250 million people in sub-Saharan Africa.

   Scientists have introduced new genes into cassava plants which enable them to produce more vitamins, minerals and protein in their tubers. A single meal of this fortified cassava a day can provide the energy and nutrients needed for that day. In poor communities where people can hardly afford more than a meal a day, the fortified cassava is all that is needed. The plant is also being engineered to enable it resist its most viral threat the Cassava Mosaic Disease. Attempt is also on to reduce the poisonous cyanide in the roots, a cause of death in consumers. Studies are also on to increase the shelf lives of the tubers for longer storage (Odeh, 2008).

ii. **Weed Control:** Much of farmers effort are devoted to controlling weeds and insects by spraying herbicides and insecticides. One major problem in the use of herbicides was how to protect the crops from being destroyed together with the weeds. This problem has been solved by genetically engineering the crops to become resistant to the herbicides. Now, weeds can be eliminated from fields of many commercially important broad leaf crops. When fields are treated with the herbicide, all the plant in the field die except the genetically engineered crop (Mader, 2001).

iii. **Insects Control:** Genetic engineers have succeeded in making many crops immune to attack by insects. The tomato plant has been engineered to be resistant to attack by insect caterpillar such as the tomato hornworm. Scientists, inserted a gene isolated from soil bacteria into tomatoes chromosomes. This gene produces a protein that converts an enzyme in the caterpillar’s stomach into a poison which causes paralysis and death of the caterpillar. The protein is harmless to humans because the enzyme is not found in man. The genetically engineered crop reduces the need for the applications of insecticides with its negative effect on the ecosystem. This technique has been used for rice, maize, cotton etc. (Tamarin, 1999).

iv. **Nitrogen Fixation:** Nitrogen is an important element needed by plants for the production of protein. The only natural source of Nitrogen is atmospheric nitrogen gas and only legumes have the ability to fix this gaseous nitrogen. To
solve the problem of nitrogen shortage in the soil, farmers have to apply nitrogenous fertilizers. Over 60 million tons of nitrogenous fertilizers were applied by farmers worldwide in 1990. Now, genetic engineers have initiated effort to transfer into crop plants, the gene that enables soybeans and other leguminous plants to fix atmospheric nitrogen. The genes needed to obtain nitrogen directly from the air are present only in certain symbiotic bacteria living in the root nodules of legumes. If this experiment succeeds, it will be possible to grow crops without nitrogen fertilizers (Tamarin, 1999).

Benefits of Biotechnology to the Nigerian Economy

i. Job and Wealth Creation: – Nigeria through the Nigerian National Petroleum Corporation (NNPC) is working towards the use of ethanol as a mixture in petrol for automobiles. The current policy in Nigeria on the use of ethanol is called E10. According to this policy, petrol whether locally produced or imported will be blended with ten percent ethanol. Bamikole (2008), has estimated that for Nigeria to meet the E10 programme, it requires 15 fuel ethanol plants each with a capacity of 200,000 liters per day to satisfy a annual demand of about 900,000,000 liters. There will be massive job creation as each plant will employ a minimum of 4000 people with the 15 plants creating employment for 60,000 Nigerians.

The use of transgenic plants by farmers will result in higher yields, because such plants will be resistant to pest and diseases, resistant to environmental stress such as drought, and do well in poor soils. The high yield combined with lower cost will likely attract more people especially the youths to farming especially if there is a guarantee that all products will be bought. Jobs are also expected to be created in the area of waste management, biological mining and in the biotechnology industries and laboratory.

ii. Food Security: A nation cannot claim to be developed when it cannot feed her citizens. The fear generated by the recent world food crises and the panic measures taken by various governments including that of Nigeria goes to buttress the point that strategies must be developed to ensure food security. Ndiribe (2008), quoting the World Bank estimated that food prices have risen by an average of 83 percent in the last 3 years and warned that at least 100million additional people could become poor as a result of this.

The recent waivers on import duty and levies on rice for six months in the first instance and the provision of N10billion credit support for farmers to boost production of rice including other government policies are temporary measures. A permanent solution to Nigerian food crises may reside in biotechnology especially in genetic engineering. Nigeria is regarded as the highest producer of cassava in the world but because it is only a carbohydrate source, the nutritional value is low. Scientists are making progress on fortifying cassava with vitamins, minerals and protein such that one meal a day will provide...
a full day’s nourishment. Unprocessed cassava tubers deteriorate within 48 hours after harvest limiting its shelf life and economic value. Scientists are also working on how to solve this problem and other constraints limiting the production of cassava. Other crops that have been genetically engineered include tomatoes, rice, maize, and cotton. Nigeria must take advantage of the advances to guarantee food security.

iii. Sanitation and Energy Supply: Cleaning the cities of refuse has been a major problem in Nigeria. With biotechnology, not only will the environment be cleared of waste materials, but they will be in fact, converted to biogas which can be used domestically as energy source. The technology is simple; a compartment called digester is built where the waste materials are digested or fermented by bacteria called methanogens.

Taylor et al (2003) reported that in the United States of America, the water hyacinth plant which blocks canals and waterways have been used to produce gas by the action of bacteria. This is now commonly used in India and China. In China, over 18 million family-scale digesters have been built to produce gas for cooking, lighting, tractors, cars and generators. In Britain, rubbish could be a major source of energy with 20dm$^3$ of gas being obtained per kilogram of wastes. This technology has a great potential for Nigeria where dealing with the waste generated in cities have become a problem.

iv. Foreign Exchange Earnings: Bamikole (2008), quoting a report in the Punch Newspaper of June 21, 2008 reported that Nigeria oil wells will dry up in 43yrs. Oil and gas reserves are estimated at about 34 billion barrels and 187 trillion cubit feet respectively (Maduemezia, 2005). Presently, the crises in the Niger Delta has reduced Nigeria oil production from the estimated 3.2 million barrels per day to about 1.8 million barrels daily. Since crude oil is the major foreign exchange earner, any disruption or drying up of Nigeria’s oil wells will be catastrophic to the economy. One solution to this problem lies in the development of bio-fuels where Nigeria has comparative advantage because of its large arable land to grow the feed stock needed for raw material. Even Saudi Arabia, the world largest exporter of oil has plans to commence Bio-Fuels production. With the search for alternative source of energy, Nigeria can become net exporter of bio-fuels.

Conclusion

Biotechnology is a goldmine in-waiting. Many people have compared it to the computer revolution that produced the likes of Bill Gates (Gottfried, 1993). Many nations both developed such USA and Britain and developing countries such as India and Brazil are already setting the stage to take advantage of the benefit of the industry in the very near future. Nigeria cannot afford to be left behind.
In spite of its prospect, several issues have been raised about the ethical and social implications of biotechnology especially genetic engineering. People have questioned the safety of human consumption of genetically modified (GM) food describing them as unnatural. The safety of the environment is also of concern especially to environmentalists who fear that a new disease – causing organism may be released accidentally into the environment with severe consequences for humans, animals and plants. Animal lovers have claimed that transgenic practices cause pain and suffering to animals. The cloning of a sheep called Dolly in 1997 raised fears that such techniques could be applied to clone man. Several governments have taken steps to ban such researches on human beings. As the debate about the extent to which scientist can go in biotechnology rages on, molecular biologists have continued to assure us that they can protect man and his environment.

**Recommendations**

In order to reap the benefits of biotechnology, the following are recommended.

i. The National Biotechnology Development Agency (NABDA) recently set up by government should be well funded and staffed to enable it formulate policies that will promote biotechnology.

ii. Research centres for biotechnology should be established in selected tertiary institutions in Nigeria. Diamond Bank is said to be building a biotechnology centre for research, science and technology at the University of Nigeria, Nsukka. Other corporate organizations should do the same.

iii. The government should draw up necessary legislation to guide the biotechnology industry especially on the protection of the environment and other safety issues.

iv. Seminars and workshops should be organized to educate the public on the benefits of biotechnology and provide the necessary information to allay the fear created by the propaganda that bio-fuels will lead to food shortage and that genetically modified food are unsafe.

v. Government should provide incentives to investors in biotechnology such as in the production of bio-fuels.

**References**


