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Applications of Food Biotechnology

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Abstract

Recently many advances in food industry represent great role of food biotechnology. GM plants and animals are used to enhance taste, shell life, nutrition and quality of food. On the other hand GM yeast and Bacteria are used to produce enzymes for the sake of food industry. These GM foods are produced by using biotechnological techniques specifically genetic engineering. Genetic engineering purpose is to introduce foreign gene of interest in an organism. This foreign gene introduction is for the purpose of enhancement in quality and quantity of food. So these techniques can be used to erase hunger from poor people of third world specially Africa. Besides positive aspects, there are some concerns. We are changing DNA that can be useful, harmful or neutral so it can result in any unexpected results. These results might include health problems. Due to these concerns, some people oppose food biotechnology. Naturalists are also against food biotechnology. According to them, genetic engineering is intervening in nature.

Keywords: Food industry; Biotechnology; Animals; Shell life; Bacteria; GM yeast

Introduction

Genetically modified food is synthesized using biotechnological tools. Modern Biotechnology is also called as genetic engineering, genetic modification or transgenic technology. In this technology, Nuclear DNA is modified through insertion of gene of interest (gene encoding desired trait). This modified DNA is called as recombinant DNA. When recombinant DNA expresses, it encodes desired product. This technology, when implemented to enhance food qualities or yield is called as food technology [1].

Modern Biotechnology is helpful in enhancing taste, yield, shell life and nutritive values. This is also useful in food processing (fermentation and enzyme involving processes). So Biotechnology is beneficial in erasing hunger, malnutrition and diseases from developing countries and third word. Modern biotechnology products are commercially reasonable hence it can improve agriculture as well as food industry that will result in raise in income of poor farmers [2]. Following are applications of Modern food biotechnology.

Role of Food Biotechnology in Food Processing

Fermentation

Breweries are synthesized through the process of fermentation. Different yeast strains are used to make breweries at commercial level. Genetic engineering has enabled us to make light wine. Yeast is genetically modified through foreign gene encoding glucoamylase. During process of fermentation yeast expresses glucoamylase that convert starch into glucose [3].

Yeast strains used for wine synthesis are capable of malolactic fermentation. Wine synthesis consists of two steps: 1) Primary fermentation results in conversion of glucose into alcohol using yeast. 2) Secondary fermentation uses bacteria and its product is lactic acid and this causes the rise in level of acidity. To overcome this problem different strategies are used which are costly. This problem was solved through insertion of malolactic gene (Lactobacillus delbrueckii) in industrial yeast strain. This gene lowers the malate conversion hence lowering acidity level of wine [4,5].

Enzymes

Enzymes are used in production and processing of food items specifically produced at industrial level. From second last decade of twentieth century, food processing companies are using enzymes that are produced through genetically modified organisms (European food information council 2015). These enzymes comprises of proteases and carbohydrases. Genes for these enzymes have been cloned so as to get higher production in less time period. These enzymes are used for making cheese, curd and flavoring food items. Major percentage of these enzymes is used in food industry as in US more than 50% of proteases and carbohydrases are used in food industry. These enzymes include rennin and α-amylase [3].

Following are some genetically modified enzymes used in food industry:

- Catalase used in mayonnaise production and it removes hydrogen peroxide.
- Chymosin useful in cheese production as it coagulates milk.
- Glucose oxidase is used in baking as it stabilizes the dough.
- α-amylase converts starch into maltose and used in baking for sweetness.
- Protease used for meat tenderization process, baking and dairy products [6].

α-amylase

This enzyme is used in the production of high fructose corn syrup (nutritive sweetener). This enzyme provides continuous process of three steps providing higher yield. Through purification this yield can be increased up to 90%. In 1986, Grant devised a system to produce α-amylase through genetic engineering using *Bacillus subtilus* as a host. Plasmid named pCPC720 was use as vector. In same year FDA approved this system of genetic engineering to synthesize α-amylase to be used at industrial level [7].

Rennin (Chymosin)

Rennin enzyme is an active component of substance rennet used in dairy industry. It is a protease enzyme used for the production of curd and cheese. This hydrolysis the peptide bond of casein proteins of milk, hence denaturing these proteins results in curd formation [8].

Previously this enzyme was extracted from stomach of calves and used to curdle milk. But through this conventional method, lower quantity was obtained. But now bacteria (*Escherichia coli*) and fungi (*Aspergillus niger*) are genetically engineered to produce rennin at commercial level [3].

Shell Life

Many juicy fruits possess short shell life. For example tomato is used all over the world. In order to be shipped, tomatoes should be picked at mature green stage. After picking, these are subjected to ethylene for ripening. Higher temperatures cause early ripening while lower temperature destroys its taste.

A Californian company named Calgene genetically engineered tomato to sort out this problem. They developed a tomato named Flavr Savr tomato. An enzyme named polygalacturonase breaks down pectin causing ripening and softening. Scientists genetically modified tomatoes to reduce amount of this enzyme. They used antisense RNA for this purpose [2]. Low amount of this enzyme results in lower breakdown of pectin and cell wall resulting in firmer tomatoes. These firmer Flavr Savr tomatoes possess longer shell life and hence support shipping [9].

Biotechnology: Improving Food Nutrition

Every food item does not contain all essential components. That's why every food article is not possessing perfect nutrition. For example rice is used as staple food in many countries of world. But being devoid of vitamin A, it's not a perfect staple food. Use of Biotechnological techniques has solved these problems through introduction of foreign vitamin A gene [10].

Proteins and essential amino acids: More than half of worldwide protein production is attained from plants but plant proteins lack some essential amino acids like lysine and sulphur containing amino acids [10]. Corn is genetically modified and it expresses proteins produced by soil bacteria *Bacillus thuringiensis* [11]. To overcome the deficiency of essential amino acids, different biotechnological molecular processes are used and given below (Table 1).

	Name of transgenic plant	Molecular pathway for modification	Enhanced Essential amino acids	Foreign genes incorporated
1	Tobacco	Synthetic gene approach	Overall amino acids	*Asp1*
2	sunflower seed	Manipulation of gene expression	Sulphur containing amino acid (MET)	Gene encoding 2S albumin
3	Potato	Manipulation of homologous protein	Mostly amino acids	*AMA1*

Table 1: Plants and food modified with amino acid genes, source of gene of interest and pathway of modification.

Vitamins and minerals: These are a compulsory food component that's why to avoid their deficiency, transgenic technology is used. Rice is one of the foods used as staple food in many countries of world. But being deficient in Vitamin A, rice is not a perfect staple food. The first provitamin rich transgenic rice was produced by incorporating *crtI* gene and *psy* gene from bacteria and daffodils [10]. Variety of provitamin rich rice can eliminate malnutrition and blindness from developing countries and third world. [11]. Scientists are working on introduction of other vitamins and macronutrients (iron, zinc etc.) genes in vitamin deficient food articles [10].

Iron: Iron is one the most important minerals required for a healthy body. The countries which use rice as a staple food are more vulnerable to iron deficiency because rice is deficient of iron [12]. To resolve this problem, rice is transformed with a foreign gene encoding iron containing gene named ferritin. Transformed rice contains double content of rice as compared to non-transformed rice [13].

Carbohydrates and lipids: Carbohydrates, lipids can be modified in transgenic plants. In late 20th century, amylopectin rich potatoes and lauric acid rich canola oil was produced through agricultural biotechnology [10]. Potatoes have been genetically modified by inserting a gene from bacteria that encode enzyme involved in starch biosynthesis pathway. These GM potatoes contain 30-60 % more starch [11].

Use of Biotechnology to Improve Yield

Milk is of the food item used all over the world due to its nutritional value. Bovine Somatotropin is a hormone released by pituitary gland. It raises the milk production. Previously this hormone was extracted from brain of slaughtered calves. But that results in low quantity. Scientists inserted gene encoding bovine Somatotropin in *Escherichia coli*. Now this hormone is obtained in higher quantity. This hormone results in 10-12% rise in milk production [12,14].

By the year 2050, population of world will become nine billion. So more yield will be requiring on same land. Biotechnology is potentially best technology to fight against problem of food yield [15].

Africa has highest level of poverty and hunger. This hunger and malnutrition results in diseases like kwashiorkor and rickets which in turn causes a lot of deaths. Biotechnology possesses highest potential to make Africa get rid of hunger, starvation, malnutrition and diseases. It can raise health standard and lower mortality rate. Three African

countries: Burkina Faso, South Africa and Egypt have already been benefitted through adaptation of biotechnological cultivation methods. For example 0.1 million farmers of Burkina Faso raised yield of cotton by 126% through use of GM food technology.

Adoption of GM food technology required system for commercial release of GMO products, tests for allergenicity, digestivity and toxicity of GM food. In this area USA and European Union should help Africa. Many African countries lack biosafety system. African should make biosafety law making and approval their priority so as to make this system adopted easily.

Another hurdle in adoption of GM food technology is lack of education. Kenyan people have a lot of concern about GM food technology and they protested against it. This attitude of Kenyan people toward food biotechnology is due to lack of education. Scientists should make people aware of pros and cons of GM food technology through conduction of seminars etc. [2].

Biotechnology: Enhancing Taste

Biotechnology has allowed scientists to produce fruits with better taste. GM foods with better taste include seedless watermelon, tomato, eggplant, pepper and cherries etc. Elimination of seed from these food articles resulted in more soluble sugar content enhancing sweetness [11]. Fermentation pathways are modified using biotechnology to add aroma in win [3].

Areas that should be subjected to improvement

Education

People opposing biotechnology and GMOs are doing this because of lack of relevant knowledge. Scientists should conduct seminars to make people aware of merits and de merits of food biotechnology So that they can make choice intelligently.

Biotechnology should be taught at high school level to make teenagers more aware of advancements and potential pros and cons of biotechnology. Education is the key thing that can develop positive attitude toward biotechnology. This is the responsibility of scientists to make a layman aware of all aspects including potential risks of biotechnology. This will develop confidence in food customers [16].

Collaboration among local laboratories and international institutes

Potential risks of food biotechnology include allergic reactions. Some cases of allergic reactions have been reported by local laboratories. Some researches proving GM food allergenic have been conducted in local labs. International institutions of biotechnology should collaborate with local labs to properly prove or falsify these results [2].

Labeling of GM food

GM food should be labeled properly so that people can make their choice on their own. There is no international labeling system. Simply two letters GM are used that are abbreviation of genetically modified [17]. People all around the world want transparent system for labeling. This labeling should be positive. Negative labeling (negative wording like "GM free") should be avoided. For effective labeling, universal standards should be developed. International labeling standards will also affect trade positively [16,18].

More research

Research is required to prove or disprove claims of local scientists against consumption of GM food. When layman asks question about potential risks imposed by GM food against ecosystem and human health, few scientist can reply. Why is so?? Main reason is lack of research related to these areas. So to commercialize GM food, scientists should have maximum confidence to support GM food and argue with people.

Potential Risks of GM Food

Risks to health

Some cases are studied at local level that showed some allergic reactions after usage of GM food.GM food contains foreign genes that can cause hypersensitivity and allergic reactions. One of the foreign protein is Cry9 that is encoded by gene present in soil bacteria *Bacillus thuringiensis* has been proved allergenic for animal feed [17]. Jia et al. [19] showed that another foreign protein OVA can cause allergic reactions (rise in level of Histamine and drop in systolic blood pressure). But further research is required to prove this [19].

Risks to environment

Another potential risk is horizontal gene transfer. Transgenic organisms when exposed to natural environment may transfer genes to other organisms resulting in spread transgene everywhere. Consequences of this spread can destroy ecosystem and other organisms. Horizontal transfer has been recorded in lab.

Conclusion

GM food technology is a one of the advanced technology of era that has potential to solve problems of malnutrition, hunger and poverty. In spite of a lot of advancements, still a large number of people oppose GM food. People should be made aware of potential pros and cons through conduction of seminars. Biotechnology should be taught at high school level to make people more aware. Biotechnology has the potential to solve many health and nutrition related problems of people of developing countries and third world. Institutes like WHO, FDA etc. should cooperate with governments of third world to make biosafety laws and commercialization of GM food.

One of the weak areas in the field of food biotechnology is labeling. Proper and positive labeling is required for successful commercialization of GM food. Other weak area is lack of research. When questions are asked about potential risks of biotechnology, many scientists can't answer. Research should be done to prove or falsify the claims against biotechnology. Debates and seminars should be conducted to raise the trust and confidence of people about GM food.

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