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Biotechnology in the Food Industry

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Abstract: Biotechnology is the method that uses biological processes of living organisms to make useful products and enhances lives. Considering the recent improvements in genetic engineering technology, which allows the specific introduction of the gene of interest, its application in the food industry is widely developing. Some applications include fermentation for food production with value-added properties like nutrition, taste, aroma, appearance, shelf life, production of enzymes, and increased yield in food production along with safe and efficient storage. It is also a likely alternative to changing consumer food trends and problems of malnutrition and hunger.
Keywords: Biotechnology, Food, Applications

I. INTRODUCTION

Biotechnology is the usage or manipulation of living organisms, biological systems, or their derivatives for the production of products or services benefiting the society. Hence its objective in the food industry is the application of animals, plants, and microorganisms to increase the efficiency, yield, and enhance the quality of products along with providing scope for new alternatives for food processing. Food processing is the conversion of raw materials or perishable goods into consumable and enduring goods, and food safety ensures that it is innocuous to the consumer.

A range of technologies exists at various levels of operation in food processing around the world. Biotechnology has been the most prevalent since ancient times like traditional fermentation methods for the production of alcoholic beverages; Preservation and production of beneficial compounds using microbes like production of enzymes for meat tenderization; Selective breeding for selection of desirable traits in crops and livestock. Since foods are biological material, any technological treatment by definition would be an application of biotechnology. Modern biotechnology is alternatively called genetic engineering. In this technology, DNA is the genetic material modified by the deletion or insertion of genes for expressing the desired trait. It incorporates these technologies in the food industry to enhance the quality, yield, taste, nutrition, and flavors of food and improve processes like fermentation. It can also benefit at the agricultural level, improving farmers' income and issues of malnutrition and hunger in developing countries. The various biotechnological processes used for manipulating microorganisms for their application in the food industry have expanded from traditional hybridization, mutagenesis, and conjugation to recombinant gene technology and various genetic manipulation mechanisms. Significant progressions in technology, primarily in molecular genetics, cell technologies, bioreactor design, protein engineering and gene cloning technology have considerably expanded the applications of biotechnology to foods.

II. ROLES OF BIOTECHNOLOGY IN FOOD PROCESSING

A. Fermentation

Fermentation is the microbial addition to enhance the property of food like the taste, nutrition, aroma, and other desirable changes and for the production of enzymes, flavors additives, and other value-added compounds. It specifically refers to the conversion of sugars to alcohol or organic acids and carbon dioxide, or the enzymatic conversion of foods to simpler molecules and the release of energy. The preparation of such foods can be locally or industrially.

The various roles of fermentation include 1) improved nutritional quality by enhanced enzymatic activity by the microbes resulting in increased digestibility and reduced anti-nutrients because of the acidic nature. 2) Increased shell life and preservative property by acidic production and antifungal activity conferred by microbes like lactic acid bacteria. 3) Detoxifying and antibiotic activity preserving the quality and taste of food. The usage of inoculants of microorganisms vary extensively, and they may be natural or genetically modified as per the need and demand. The various properties and role of fermentation are improved using genetically engineered tactics like producing microbes that can grow at a faster rate than contaminants or produce antimicrobial agents to inhibit and destroy pathogens or with increased viability.

Like in breweries, GM brewer's yeast are used for low carbohydrate beer production by introducing the glucoamylase gene from Aspergillus niger. In winemaking, yeast strains are genetically modified for reduced malolactic fermentation capacity by inserting genes from Lactobacillus delbrueckii, thereby reducing the acidity of the wine.

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B. Preservation

Biotechnology is an alternative for synthetic chemicals in food preservation; these include the addition of protective culture like lactobacillus sp. or microbial metabolites, which are antagonists to pathogens or increase shelf life like organic acids, hydrogen peroxide, reuterin.

Microbial cultures used in the processing of foods can be themselves genetically modified for the production of such compounds and degradation of natural toxins.

Some examples of preservation include recombinant antifreeze protein in fruits and vegetables, which offer cryogenic protection and genetic modification of tomatoes to reduce the enzyme polygalacturonase by inserting its antisense gene. Polygalacturonase is responsible for the breakdown of the cell wall and pectin, causing softening and ripening of tomatoes; hence the degradation pace of the tomato reduces and is called Flavr Savr tomatoes.

C. Enzymes

Enzymes are organic catalysts that speed up the rate of reactions within living cells. They have been used since ancient times by man by using naturally occurring microorganisms that release them for the production of foods like bread, cheese, drinks, and fruit juices.

They generate desirable flavors and essences and can also improve texture, nutrition, and form. Currently, enzymes can be obtained from plants and animals, and mostly from a range of beneficial microorganisms. Enzymes are an alternative for chemical-based food production and are more beneficial as they are more specific and confer fewer side effects, increasing the quality of production. Being biodegradable and having low energy requirements it is environment friendly as it hardly causes pollution.

The derivation of most of the enzymes currently used in food industries is from genetically modified organisms. These are cultured in large amounts in fermentation vessels under appropriate conditions and extracted as their metabolites. They are further purified by a series of filters to get valuable enzymes.

The engineered organisms confer advantageous properties like increased enzyme productivity and specific characteristics to suit the needs of the industry. These include the capacity to work at high temperatures or increased pH and efficiency with new substrates. The strains could also be engineered for deleting genes producing toxic metabolites or extracellular proteases that hamper enzyme production.

A large extent of enzymes used in the food industry is carbohydrases and proteases majorly alpha-amylases for cornstarch processing and renin (chymosin) in the cheese industry for coagulating milk. Renin was obtained conventionally from calves' stomachs and can now be produced from *Aspergillus niger* and *Escherichia coli* by genetic engineering.

α-amylase can produce high fructose corn syrups by amino acid sequence modification, which leads to increased thermal stability. Other modified enzymes used in the food industry include chymosin in the dairy industry, glucose oxidase for baking, and catalase in mayonnaise production.

D. Enhancing Taste

Various bioengineering techniques have produced products with increased sweetness, aroma, and many artificial flavors and chemicals. It can be achieved by modifying at the agriculture stage or using microorganisms and metabolic engineering of biosynthetic pathways for production or implementation of rDNA technology for increasing yield of sweeteners like aspartame and thaumatin. Fruits like watermelon and cherries developed without seeds, which leads to more soluble sugars boosting their sweetness.

E. Nutrition

Most often, a single food does not contain all the necessary nutrients in it and hence is insufficient to meet the needs of compromised populations, especially in developing countries. Sometimes existing nutrients in food are lost during their processing, like cooking. Biotechnology and genetic modification techniques have developed fortified foods for the improvement of the nutritional value.

Like Golden rice, transgenic rice produced with genes for beta-carotene synthesis, a precursor of Vitamin A. This is by incorporating *crtI* gene and *psy* gene from bacteria and daffodils for overcoming problems of populations with vitamin A deficiency that was leading to malnutrition and blindness. Rice, being a staple food in the majority of the population, was an efficient crop for tackling the deficiency. Other examples include potatoes that are modified for more starch and amylopectin, canola oil with increased lauric acid, and ferritin incorporation in rice to cope with iron-deficient populations.

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F. Agriculture and Livestock

The conventional techniques for improving functional attributes involve the selection of desirable traits in plants and animals by selective breeding. However, the possibilities were countless and unpredictable as the transfer of undesirable traits was inevitable, and the breeding had to be limited to the same or close species making the technique inefficient. In agriculture, farmers often used fertilizers and pesticides to increase crop yield; however, it had many disadvantages, like increasing environmental pollution and cost.

New applications of biotechnology lead to improved yield and productivity in plants and animals, such as improved breeding techniques like artificial insemination, DNA screening for undesirable genes, and use of molecular markers for trait improvements like disease resistance, growth and meat quality.

Biotechnology has been harnessed in the agriculture industry by new breeding strategies for plants allowing intergeneric gene transfer. Tools like microinjection, Agrobacterium-mediated gene transfer allow hybridization and cellular level manipulation by introducing desirable genes like pest resistance, drought, heat, or cold for production of hybrid seeds.

Like, Bt.cotton, which is genetically modified cotton with bt toxin genes, the cry genes from *Bacillus thuringiensis*. It can kill insects by getting activated at alkaline pH in the insect gut causing it to bind to the epithelial cells creating pores leading to the cell to swell and lyse killing the insect preventing crop damage.

III.CONCLUSIONS

The benefits of biotechnology dominate its importance in the food industry. The recent drift in food habits and consumer lifestyle in developing and urbanizing countries has increased the scope of new products in the market and production of existing food products at a larger scale. Biotechnology is the key solution to meeting complications of food yield and quality for the increasing demands of population, poverty, and hunger. It provides an environmentally safe and chemical-free alternative for food production. The technologies and practices must not affect the safety of food and ensure its characteristics do not pose a threat to public health.

The primary deciding factor for the use of biotechnology in the food industry depends on the consumers' needs and demands. It principally includes social and economic factors. The development of a country also affects the production of high-value products obtained using new technologies for various applications.

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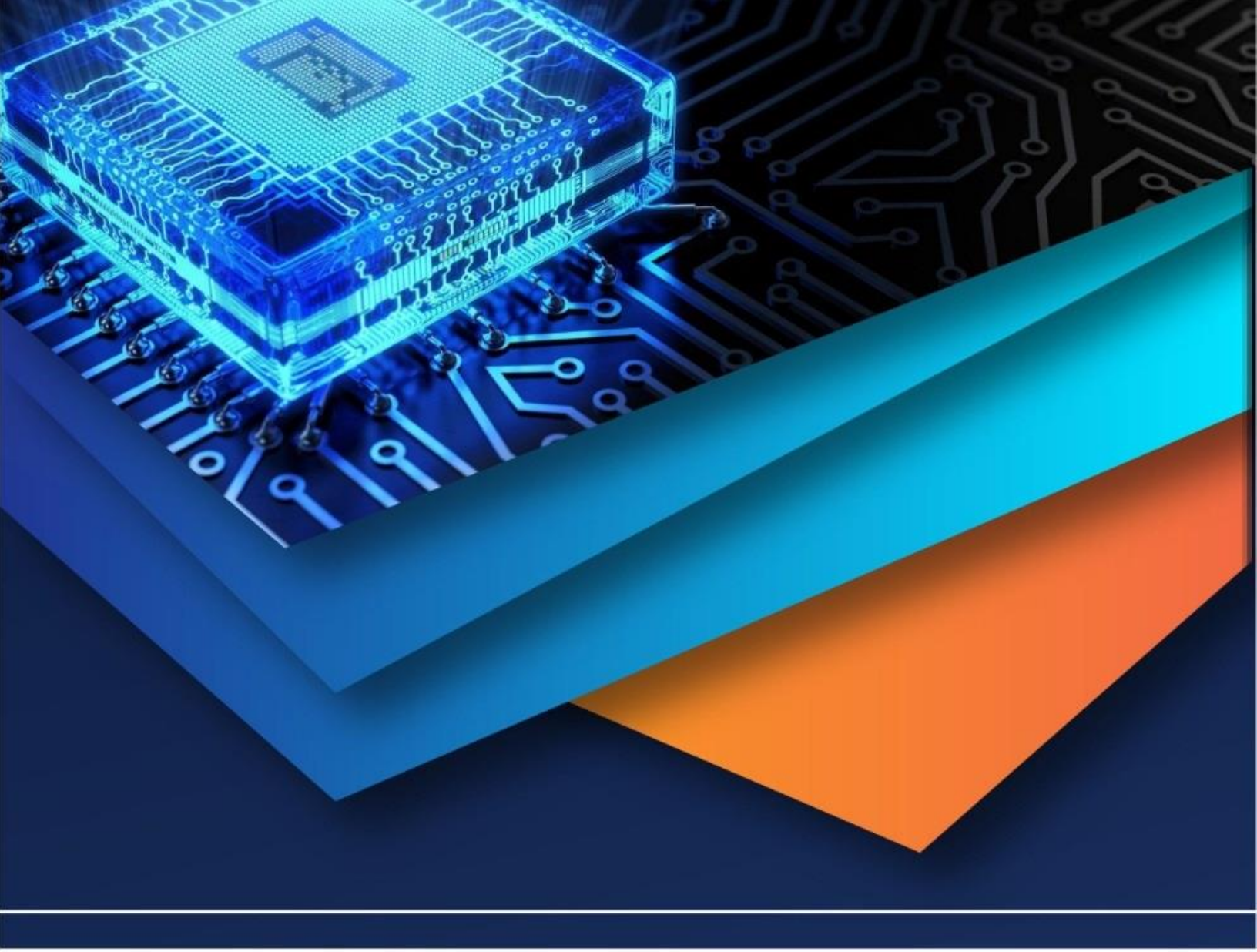
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