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Application of Bio-Technology in Human food Processing and Animal Feed

Research Article

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Abstract

The food business has a lot of opportunities because to biotechnology. In the dairy, meat, fish, and beverage processing industries, biotechnological approaches are used to improve the nutritional, functional, and sensory qualities of food. Biotechnological solutions, when used strategically, can assist reduce the quantity and number of unhealthy elements in foods, as well as remove allergenic substances. As a result, food biotechnology contributes greatly to resource conservation, harvest yield optimization, and the production of healthier and better foods. For thousands of years, people have consciously employed the properties of microbes and their enzymes in food production. The progress of food processing has been aided by biotechnology. It can also combat the present global food and nutritional insecurity concerns.Biotechnology also plays a role in improving animal feed in three ways: adding value to forage used as animal feed, producing feed additives, and manipulating rumen microorganisms to optimize feed utilization. Know a day when there is a shortage of animal feed in most parts of the world, and the price of feed ingredients is rising; indicating that feed usage is improving. The developing world is home to the majority of the globe's people. As a result, biotechnology plays an important role in improving livestock feed in order to meet the needs of both animals and humans. Many biotechnological techniques can be applied to quality assurance systems, which are critical for producing high-quality livestock products that are safe for human consumption.As a result, the goal of this review is to look into the role or application of biotechnology in improving livestock feed.

Keywords: Biotechnology; Food Biotechnology; Animal Feed; Future Perspectives And Recommendation.

Introduction

Food processing can be defined as the application of various operations and technologies to convert relatively bulky, perishable and typically inedible raw food materials into more useful shelf-stable and palatable foods or potable beverages [45]. In the present era, there is a growing concern about production of low cost, healthy, safe, nutritious, and value-added food products to improve human health. Biotechnology is a diverse field of science, which has been instrumental in human development ever since life has evolved. Historically, it could be dated back to 4000 BC, when man had started using microbes to produce bread and wine. Basically, it integrates human, animals, and microorganisms with the technology for the betterment of life. The research in cell biology, animal sciences, environmental sciences, plant sciences, agriculture, food, and medicine are among a few important areas where biotechnology, and its applications play a key role [25].

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). His 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 [30]. 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 [1].

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Pharmaceutical industry is another area where biotechnology has given a great boost, and has played an important role in the discovery of antimicrobial agents [32]. Production of quality food, paper from the trees (Biopulping), synthesizing fuel from various raw materials, and selective breeding (Bioplastics) with minimal cost and pollution are other significant contributions of biotechnology. Major tools of biotechnology include tissue culture, selective breeding, fermentation, DNA finger printing, and recombinant DNA technology [11, 21]. Biotechnology also finds its place in the diagnosis of various genetic disorders, and infectious diseases, by allowing complete genetic/DNA analysis, thereby finding ways to treat them [23].

Traditional methods of livestock improvement have been used in the past year and served the purpose of increasing livestock productivity for meeting the requirement of the world. But this method can no longer sustain production; consequently, new intensive techniques including biotechnology are now required to increase productivity of animals by using different alternatives. Today, biotechnology has able to provide new opportunities for meeting enhanced livestock productivity in a way that alleviates poverty, improves food security and nutrition and promotes sustainable use of natural resources [4].

In animal feed, biotechnology can improve the plane of nutrition through protection of protein, amino acids [46] and fat [40]. Use of enzymes to improve the availability of nutrients from available feed and to reduce the wastage of the feed, prebiotics and probiotics to inhibit enteric pathogenic bacteria, use of plant biotechnology to produce feed and fodder with good nutritive values can be done, genetic manipulation of rumen microbes to improve the animal health.

Animal feed and feeding practices are being changed by biotechnology to improve animal nutrition and to reduce environmental waste. Improvements have largely comefrom dilution of maintenance [6], while other improvements can come from increased digestibility or nutrient availability from feeds, reduced non-productive days for dairy [24] or genetic selection for feed efficiency [8]. Therefore, the objective of this work is to review the application of biotechnology on human food processing and animal feed improvements.

General Aspect of Food processing and Animal feed in relation to Biotechnology Application

Processing assures food security by minimizing waste production and reducing the food chain and increasing food availability and marketability. The purpose of food processing is to improve its quality and security. Food safety is a scientific discipline, which ensures that a particular food will not be the reason of any injury to the consumer when it is manufactured and eaten according to its deliberate use. Biotechnology plays a pivotal role to improve the taste, flavors, color, texture, aroma of foods, and its aesthetic and nutritional value; it is extensively used in many countries. Food undergoes fermentation by intentional inoculation or by natural fermentation and eventually these desirable changes appear due to fermentation by microorganisms and/or their enzymes, flavor, fragrance, food additives, and other value-added products. These high value products are used in food and nonfood use and also imported to other countries.

Food processing involves various unit operations and techniques to convert raw, perishable, and inedible products to consumable form with enhanced quality and shelf life. To produce a safe and high-quality food, the process and manufacturing protocol used in the food processing must be of food grade, that is, free from health hazards. Safe food can be defined as the food that contains no harmful components that affects human health and nutrition. Biotechnology is also widely employed as a tool in diagnostics to monitor food safety, prevent, and diagnose food-borne illnesses and verify the origin of foods. Techniques applied in the assurance of food safety focus on the detection and monitoring of hazards whether biological, chemical, or physical. Fermentation is generally used to make desirable changes in food. Fermentation can be carried out naturally or by intentional inoculation. Fermentation is the process in which carbohydrates are converted into alcohol and carbon dioxide or organic acids when yeasts, bacteria, or a combination of them works on the food in the absence of air. Fermentation is used to produce wine, beer, cider, leavening of bread, and lactic acid.Fermentation, useful for conversion of sugars and other carbohydrates into preservatives and other organic acids, generally used in food processing as it:Modifies diet by enrichment of flavors, aromas, and food texture;Preserves food by production of acids;Enriches food with protein, essential amino acids, and vitamins; Removes antinutritional factors; and-Decreases process time.

The major role of biotechnology on livestock production is increasing the livestock feeds through improving nutrient content / value as well as the digestibility of low-quality feeds like roughage through use of different chemicals for example feed additives. In animal nutrition, biotechnology can improve the plane of nutrition through protection of protein, amino acids [46] and fat [40]. Use of different enzymes to exploit the availability of nutrients from feed and to reduce the wastage of the feed and fodder, immune supplements to inhibit pathogenic bacteria to the animals, use of plant biotechnology to produce feed and fodder with good nutritive values, addition of antibodies in feeds can be used to protect the animals from the disease, genetic manipulation of rumen microorganisms to improve the animal health and growth.

Applications of Biotechnological in Food processing

There are various food processing sectors where the biotechnological tools can be applied for betterment of the food products. These aspects include increasing the yield of food, improve the nutrition value, use of fermentation process to yield different food products, producing important enzymes, increase the shelf life, improving the organoleptic properties of food, and to enhance the food safety [27].

Biotechnology to Increase the Yield of Food: Transgenesis includes manipulation of a gene of one organism in to another organism of same or other species in a way that the gene is both expressed, and is also transferred to the next generation [48]. Transgenic swine was developed by inserting plant gene, which revealed high level of unsaturated fatty acid in their muscle mass and considered as healthy pork [33].

Biotechnological Application in Fermentation Process: In commercial fermentation processes, to produce different value-added fermented foods, starter cultures have been developed to

utilize as inoculants. "Starter cultures" made up of single or mixed strains of microorganisms have been found beneficial [17]. Inhibitory activity of these cultures was noted due to the production of one or several substances such as diacetyl, bacteriocins, hydrogen peroxide, and organic acids [18]. Protoplast fusion, cloning, plasmid transfer, and transduction of defined starter cultures were used to explore possibilities to improve anti-cholesterolemic property, defense, resistant against enteropathogenic microorganism, and anti-carcinogenic activities of livestock foods [43]. The fermented dairy products have very good health benefits and influence the intestinal health [5]. Lactobacillus strains can be used as potential probiotics for the preparation of fermented dairy and meat products having great health importance [36]. So, the biotechnological tools can be used to produce improved strains of bacteria, yeast, and moulds, which can be used for the preparation of fermented meat and dairy products.

Biotechnology to Improve the Nutritional Value of Foods: Every food item does not contain all essential components so every food is not possessing perfect nutrition. With the advances in the biotechnology, bio-fortification of foods using technologies such as recombinant DNA technology and fermentation procedures is gaining advantage in the industry [7]. Designer foods are normal foods fortified with health promoting ingredients [3]. The term was introduced in Japan in 1980s for referring processed food containing nutrient conferring of some additional health benefits apart from its own nutritional value [10].

Reports also suggested that selenium (Se)- enriched chicken, pork and beef can also be produced by feeding organic Se in the diet of poultry and farm animals [16]. Designer food or functional foods are gaining greater importance due to their role in disease prevention and health promotion [16].

Biotechnological Applications to Produce Enzymes: Humans have been utilizing enzymes throughout the ages, either in the form of vegetables rich in enzymes, or as microorganisms employed for a variety of purposes, for example in cheese production, baking, and brewing [20]. Today, microorganisms are an important source of commercial enzymes. Biotechnology encompasses the most accurate methods to produce enzymes by optimizing microorganisms. These methods are used to acquire high yielding enzyme producing organisms [47].

Some individuals might have lactose intolerance and intricacy in consuming milk and dairy products due to less efficiency of intestinal enzyme (β-galactosidase). Some researchers had produced microbial met from different organisms to make it commercially available with low-cost. Previous reports have noted that various animal or microbial lipases were used to make pronounced cheese flavor, with low bitterness, and strong rancidity, while lipases in combination with proteinases and/or peptidases gave good cheese flavor with low levels of bitterness [41].

Biotechnology to Increase Shelf Life of Food: Since long time, shelf life of food and beverages are extended by bacterial fermentation of perishable raw materials. Most of the food fermentations involve conversion of sugars to lactic acid by lactic acid bacteria (LAB, which include the genera of Streptococcus, Lactococcus, Lactobacillus and Pediococcus). Lactobacilli have gained attention nowadays, due to the production of bacteriocins [9]. These substances can be applied in the food industry as natural preservatives. The use of LAB and of their metabolic products is generally considered as safe (GRAS, Grade One) [35]. By providing controlled environment to a specific bacterial culture, bacteriocins of the choice can be obtained. Nisin is the only bacteriocin that has been officially employed in the food industry and its use has been approved worldwide [22]. Not only the use of nisin-producing lactic acid bacteria (LAB) as a fermentation starter culture but also the direct addition of nisin to various kinds of foods, such as cheese, margarine, flavored milk, canned foods, and so on, is permitted [12]. Pediocin PA-1 is another bacteriocin from LAB, which is widely distributed and is more potent in inhibiting the growth of several pathogens associated with food spoilage and food related health hazards so can be explore as a potential food bio-preservative agent [37].

Biotechnology to Enhance Organoleptic: Characteristics of Food The organoleptic quality of the food can have significant effect in acceptance of food and food products by consumer. The techniques of genetics (selection, molecular biology, transgenesis) and the biotechnologies will play a major role in the evolution of quality mainly for the chemical-nutritional and technological characteristics and for some organoleptic aspects [44]. Microbial cultures used in food production are often referred to as starter cultures that can also enhance the organoleptic quality of foods. Fermented foods are value added products which have higher nutrients, prolong shelf life and easy in digestibility and are more suitable for the intestinal tract [44]. The organoleptic qualities of such foods are higher particularly in terms of flavor, taste, aroma and color [42]. The attraction of producing flavor and color by biotechnology is great. Recombinant DNA technologies have also enhanced efficiency in the production of non-nutritive sweeteners such as aspartame and thaumatin [14].

Biotechnological Applications to Enhance Food Safety: Unforeseen and inadvertent compositional changes occur with all forms of genetically engineered foods. The European Food Safety Authority has concluded that bacteria used for or in feed production might pose a risk to human and animal health because of carrying acquired resistance genes [13]. Ensuring as satisfactory level of food quality and safety is utterly indispensable to endow with adequate safeguard for consumers and to facilitate trade. Careful monitoring of microbial contamination in the final product as well as monitoring of the production process and cleaning and sanitation is one of the most essential factors of the manufacturing process in food technology and biotechnology [34]. Proteomics and genomics technologies offer further, more sensitive and specific methods for recognition of microbial food contaminants and their toxins. Various powerful tools of biotechnology, which have already made enormous advances, include genetic engineering, PCR (polymerase chain reaction), random amplified polymorphic DNA (RAPD), amplified fragment length polymorphism (AFLP), rDNA technology, MALDI-TOF MS (matrix associated laser desorption ionization-time of flight mass spectroscopy) [31]. These methods can also help in meat authentication and to check meat speciation. Expansion and development of new novel methods for rapid revealing of emerging high-risk food pathogens in livestock foods is tremendously imperative in context of food safety.

Application of Biotechnology in Animal Feed Improvement

Increasing digestibility of low-quality forages: Know day

low-quality forages are a major feed component of ruminant diets in most of the world. Thus, much progress can be made by improving their quality by different way. The characteristic feature of tropical forages is their slow rate of microbial breakdown in the rumen with the result that much of the nutrients of the feed are voided in the faces. This results in reduced outflow rate of feed residues from the rumen which consequently depresses feed intake of the animal [26]. At present, the main treatment methods for low quality forages such as cereal straws are either mechanical like, grinding, physical like, temperature and pressure treatment or a range of chemical treatments. The lignification of the cell walls prevents degradation feed by cellulase enzymes.

Improving nutritive value of cereals: According to [39] moderate protein content and low amounts of specific amino acids limit the nutritive value of cereals and cereal by-products. This is a major disadvantage in the ration formulation for non-ruminant livestock which necessitates addition of expensive protein supplements. There are on-going studies to enhance the low level of lysine in barley by genetically engineering the grain genome. Genetic modification through insertion of genes into rice protoplasts and generation of transformed plants has already been achieved.

Removing anti-nutritive factors from available feeds: Anti-nutritive factors in plant tissues like, protease inhibitors, tannins, and cyanogens in legumes, and glucosinolates, tannins and sanapine in oilseed rape and other compounds in feeds. As with amino acid deficiencies, the adverse effects of these compounds are more marked in non-ruminants than in ruminants. Conventional plant breeding has been used to reduce and, in some cases, eliminate such anti-nutritive factors from the feed. An example is the introduction of cultivars of oilseed rape which are low in, or free from erucic acid and glucosinolates. A combination of genetic engineering and conventional plant breeding should lead to substantial reduction or removal of the major anti-nutritive factors in plant species of importance as animal feeds [2].

Improving nutritive value of conserved feed: The conservation of plant material as silage depends upon anaerobic fermentation of sugars in the material which in turn is influenced by the ability of naturally occurring lactic acid bacteria to grow rapidly on the available nutrients under the existing environment. Other ways the ensiled material is sterilized, lactic acid bacteria are always present. However, the ensiling conditions may not always be ideal for their development. In addition to the number and type of bacteria, other factors may affect quality of conserved silage, like, availability of water-soluble carbohydrates, the dry-matter content, the pH, etc. Let's take an example; lack of water-soluble carbohydrates may be overcome by wilting the material to raise the dry matter to a level at which less acid is required to stabilize the fermentation [39].

Improving rumen function: Malmuthuge, and Guan (2017) [29] reviewed the major areas of rumen roles which might benefit from transgenic technology. These include development of transgenic bacteria with enhanced cellulotic activity, able to cleave lingo hemicellulose complexes, reduced methane production capability, increased capacity for nitrogen "fixation" and increased ability for microbial production of specific amino acids. But we are still a long way from commercial production of genetically engineered rumen bacteria; advances being made in transformation methods for obligate anaerobic bacteria will certainly result in successful genetic engineering of a range of rumen bacteria.

Effects on microbial population and ruminal functions: Yeast cultures are very important in the rumen. Different studies showed positive effects of yeast culture not only on the rumen environment, but also on the improvement of microbial activities. Yeast supplements imitate the growth of beneficial microorganisms in the rumen. For example, the numbers of total ruminal anaerobes and cellulolytic bacteria have been increased with yeast culture [15]. In this way, they influence the rate of volatile fatty acid production and, thus, increase the stability of rumen environment and improve the intensity of digestion.

Metabolic modifiers: Metabolic modifiers like, recombinant bovine somatotropin have been used to increase efficiency of production such as weight gain, improve carcass composition, researchers have also developed porcine somatotropin that increases muscle growth and reduces body-fat deposition, resulting in swine that are leaner and of greater market value metabolic modifiers are a group of compounds that modify animal metabolism in specific and directed ways. They have the overall effect of improving productive efficiency (weight gain or milk yield per feed unit) improving carcass composition (lean to fat ratio) in growing animals, increasing milk yield in lactating animals and decreasing animal waste per production unit [38].

Potential risks of genetically modified Food and Feed

Food Risks to health

At the local level, several examples of allergic responses following the consumption of GM food are being investigated. Foreign genes in GM foods can trigger hypersensitivity and allergic responses. Cry9, a foreign protein expressed by a gene found in the soil bacteria Bacillus thuringiensis, has been found to be allergenic in animal feed [28]. Another foreign protein, OVA, has been shown to elicit allergic reactions by [19]. Rise in level of Histamine and drop in systolic blood pressure). However, more research is needed to establish this [19].

Risks to environment

Horizontal gene transfer is another potential danger. When transgenic organisms are exposed to the natural environment, they may transfer genes to other creatures, causing the transgene to spread across the ecosystem. The effects of this proliferation have the potential to damage ecosystems and other organisms. In the laboratory, horizontal transfer was observed.

Future Perspective and Recommendation

Genetically modified food and feed technology is a one of the advanced technologies 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 has the potential to solve many health and nutrition related problems of people of developing countries and third world.

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.

Therefore, the following recommendations can be made: in many countries and regions as possible, put major emphasis on local research to manipulate through feeding technology of the microbial ecosystem of the rumen and the animal's metabolism to make ruminants efficient on feeds that are locally available. The most important thing is the introduction of supplements to the available feed resources at poor quality feed in order to improve its nutritional value. Modern biotechnologies should also be developed worldwide. It is emphasized to undertake further research for improvement in safety of processed food products. Embracing the potential of biotechnological applications should be done cautiously, keeping in mind the natural ecological niche.

Conclusion

Biotechnology has already made significant contributions to livestock, and food industry. Modern biotechnology is helpful in enhancing taste, yield, shelf life, and nutritive values of food. It is also useful in food processing (fermentation and enzyme involving processes). Hence, biotechnology can be used for the benefit of human health, and eliminate hunger, malnutrition and diseases from people living in developing countries, and poor countries. It is imperative to consider any potential human health or environmental risks when foods are developed using biotechnology.

Moreover, Biotechnologyin animal feed application can be concluded that there are several potential opportunities for improving the efficiency of ruminant digestion and possibilities for utilizing a wider range of feeds than is currently possible. Genebased technologies are being increasingly used to improve animal nutrition, through conservation of feed stuff in a form that keep or even improve its nutrients. Adopting biotechnology has benefitted by in animal improvement and economic returns to the livestock entrepreneurs and small producers. Fibrous feeds, including crop residues, of low digestibility constitute the major proportion of feeds available to most ruminants under smallholder situations in developing world. So, this is the time, when investment in biotechnology and animal nutrition is important for sustainability of human and animals, food security and wealth creation and used for poverty reduction of poor people living in the villages.

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