USE OF ENZYME TECHNOLOGY IN FOOD PROCESSING INDUSTRIES

Abstract

The food sector often uses enzyme technology because of its efficiency, specificity, and safety benefits. Recent years have seen "future foods" emerge as a new hotspot for developing healthier, more nutrient-dense, palatable, and sustainably produced meals. Nonetheless, many meals have consistency, nutrition, and flavor concerns. Enzyme technology advancements have enabled the development of new tools and ways for modifying the feel of foods and caloric components. In this paper, we explore the applications of enzyme innovation to the production of potential meals, with an emphasis on taste, consistency, and security. Additionally, we examine the prospective alternatives of catalyst-based innovations regarding food production, both of such as the customization of enzyme activity, the development suitable hosts to produce of meal-grade amino acids, and the further development of combinatorial multi-enzyme complexes.

Keywords: Enzyme technology, Texture, Nutrition Security.

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I. INTRODUCTION

Food science has transformed from traditional ways for nutritional enhancement, such as mechanical processing of food, as biological studies and food manufacturing have developed. Components, as well as modern food manufacturing or designing. Future food production will be dependent on advances in biological engineering, machine learning, manufacturing by additives, and flavor (Fig. 1) [1]. In the future, mitochondrial and enzyme science will be used alongside traditional food manufacturing technologies, for instance establishing biosynthetic pathways to turn renewable raw materials into food components and beneficial nutritional supplements. These technological breakthroughs will address difficulties concerning the global food provides safety, hygiene, and stability as enhancing nutrition technological and scientific advances [2, 3].

Future food production employing cell culture has the potential to expand land utilization by 1,000 times, consume > 90% less water, and emit 87% less greenhouse gas than traditional food businesses [1, 4]. In terms of health, safety, nutrition, and environmental effect, foods like artificial meat (including plant-based and cell-cultured varieties) outperform traditional meat production in a big way. Impossible Foods Inc., Beyond Meat, and Memphis Meats are current biotech firms that have spent money to create and market fake meat and other future foods.

Food processing requires the creation of effective methods for modifying and improving synthetic meat's flavor, texture, and nutritional qualities. Enzyme-based technology has emerged as a potent instrument for the fast expansion of the food industry since it cuts down on processing time, material costs, and energy requirements while being non-toxic and environmentally beneficial [5, 6]. As an illustration, glutamate amino acids (TGase) as digest were tuned to change the amount of linking and breakdown toxins and quality enhancement during food preparation [7].

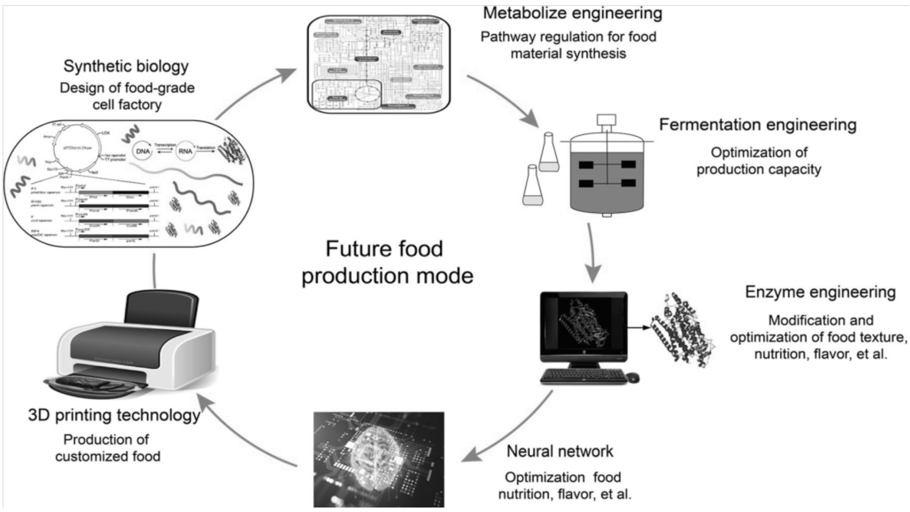

Figure 1: The Growing of Food for the Coming Years.Manufactured production of food in the future would entail several sophisticated methods that involve artificial brains, microbial technology, metabolic design, nutrition artificial life, protease a career in engineering or the technology of 3D printing. (Reference No. (79) (2020) Progress and possibilities from enzyme manufacturing for subsequent meals).

Currently, enzymes are also used to improve nutritional aspects and utilization efficiency of raw materials and provide methods to customize flavor profiles of food (Fig.2). This review focuses on the applications of enzyme technology in future food production, including food texture improvement, nutritional safety enhancement, and flavor optimization (see Table 1). Furthermore, the prospects of enzyme technologies are also discussed.

II. APPLICATIONS OF ENZYME-BASED TECHNOLOGY IN FUTURE FOOD PRODUCTION

1. **Food Texture Improvement:** The quality of food is significantly influenced by texture, which makes it a prime candidate for structural and function modification via enzyme technologies. This enzyme, for example, may promote the bonding the amino as well as argentine protein remnants in meat products, reducing the volume of raw materials required for manufacture and providing meat products with a feel similar to whole raw tissues [8]. As compared to the traditional chemical approach that incorporates plenty of chlorine or phosphate of sodium salts as well, TGase-processed beef offerings are significantly better for you [9].Milk proteins, minced fish, and sausages have been processed using TGase. The gel texture is improved by this cross linking. By boosting the gel's water-holding capacity, viscosity, and stiffness [10]. However, due to its lack of enzymatic capabilities and restricted residue substrate range, TGase has just a few cross linking uses [7]. Other enzymes, such as lactase, are capable of linking proteins found in milk by forming covalent bonds between tyrosine residues. [11], Lactase may improve the elastic attributes of milk that is skimmed jellies. [12]. additionally, protein cross linking may be accomplished by polyphenol oxidase [13]. When Li et al. investigated the cross linking influence of the horseradish peroxides enzyme on casein in the absence of hydrogen per oxide, they reported that casein emulsification climbed by ten percent and the stability of the emulsion grew by six percent during attaching. [14]. additionally, a significant approach for modifying protein texture is the covalent fusing of fatty acids with proteins [15]. For instance, fatty-acylated proteins can alter the chemical and physical structural characteristics of proteins derived from plants to increase their ability to store oil.

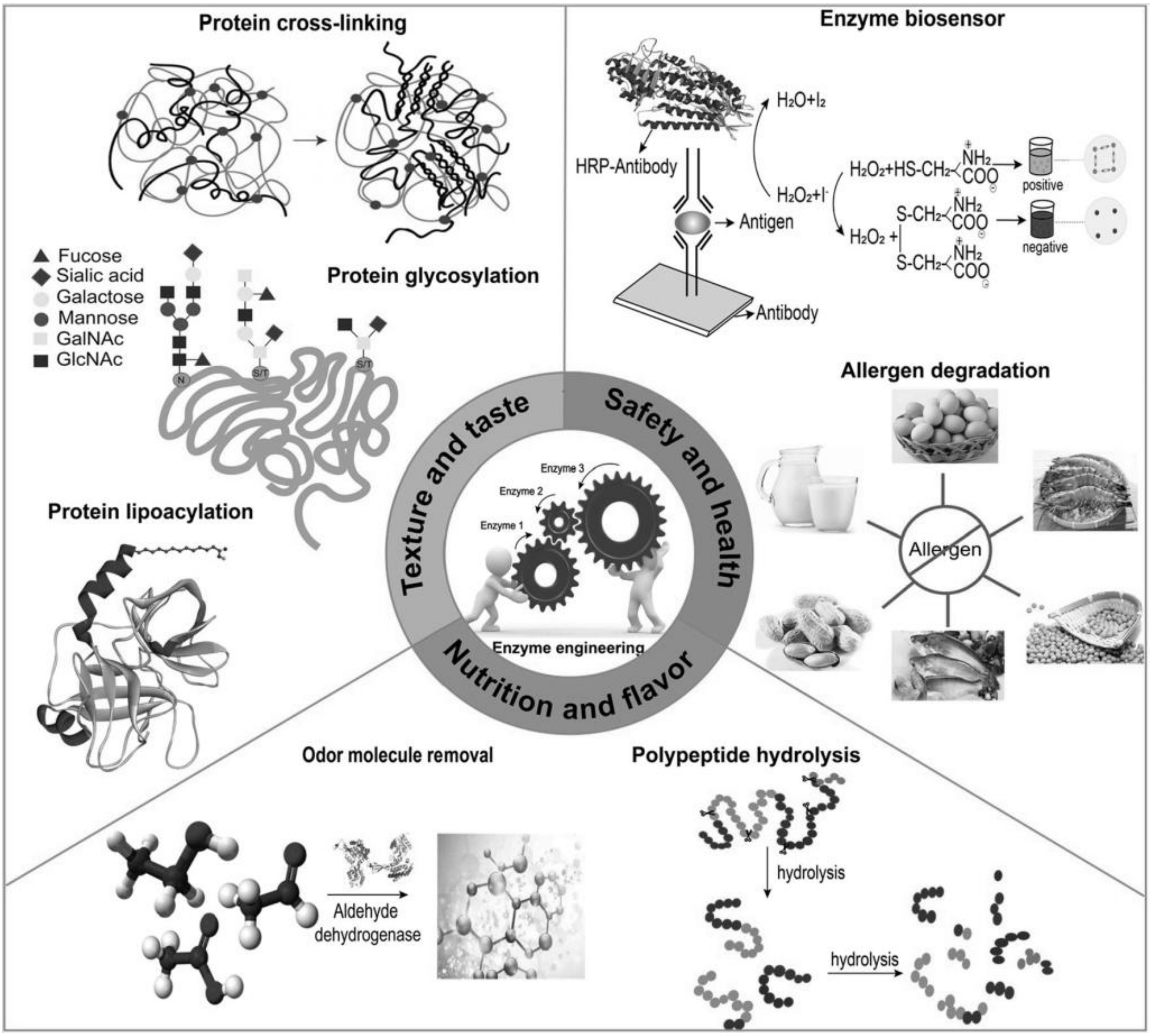

Figure 2: Enzyme-based technology applications in future food areas. Enzyme-based innovations are primarily employed in the enhancement of future food production structure, nutrition, colour, and aroma, but they are also used in the inspection of meal components or identifying the presence of pathogens, antimicrobial agents, and contaminants. (Reference no. (79) (2020), Actual Status & Expectations on Starch Technology in Upcoming Meals .

2. **Food Hygiene:** Allergies to certain foods and antibiotic exposure have heightened citizen worries regarding meal hygiene and safety. [16]. Because of hypersensitivity towards -conglycinin & bean globulin itself amino acids derived from plants such as soy amino acids are prohibited. [17], to prevent or mitigate wellness issues, it is critical to reduce the proportion that contains these offenders in future food manufacture. Numerous investigations [18] have shown that the proteases papain and pepsin may hydrolyze soybean allergens and diminish allergenicity. Chymotrypsin's breakdown of 11S glycinin significantly reduces its allergenicity, according to "Lee et al." [19]. Particularly juxtaposed with existing both chemical and physical approaches, characterized by worse manufacturing parameters, less discriminating (degrade both antigens), and greater hazards [20], enzyme-based treatments offer a considerable benefit in minimizing allergenicity. Amino variations (which include acetylating) are an additional therapy for a food-based protein allergy symptom. The antigen city of glycerin (11S) dropped by

approximately 30% complying with glycosylation, implying perhaps glycosidase could represent a useful agent in reducing allergy symptoms to products made from soybeans. [21]. Equestrian drugs, particularly amoxicillin and cephalic acid, are widely used in the yoghurt trade. Because of the excessive usage of these antibiotics, milk, and meat products can frequently get contaminated [22, 23]. As a result, creating economical and accurate enzyme-based gadgets for measuring the content of goods could help maintain food quality. [24].

To make wholesome and nutrient-dense food, it is necessary to reduce allergies, antibiotics, and other hazardous components in raw materials. The use of enzyme technology might make food processing in the future safer, more efficient, and environmentally beneficial. These enzymes might be made using microbial fermentation, which provides scalable extraction techniques, affordable manufacturing prices, and small industrial footprints. Fermentation may also supply tailored enzymes to eliminate particular sensitivities and dangerous substances.

3. **Nutrition and Flavor Enhancements:** To address the increased demand for edible nourishment, culinary scientists are constantly coming up with novel approaches to enhance the taste profile and boost nutrition. Through the enzymatic decomposition of animal or plant sources, the utilization of enzymes improves the appearance of colures, aroma, and nutritional content of meals. Veggie proteins [25]. From catalytic hydrolysis products and other shiitake collagen ingredients, heat can be used to make beef-flavored additions that consist of a drug called hydrazine, diazole, and cytosine. [26]. Polyunsaturated acid, which may be produced by the host bacterial organism a strain of biolytic by harboring two denatures alleles from the mould Mortierella alpine, is additionally crucial for the creation of flavor in some false meals. [27].

Cheap protein sources may be transformed into specialty foods with excellent nutritional content and unusual tastes via enzyme modifications. People can consume hydrolysates without experiencing adverse responses since they function as beneficial nutritional taste enhancers and antibacterial agents [28]. According to recent studies [29, 30], these hydrolytic polypeptides help lower oxidative stress, type 2 diabetes, and hypertension. As consequently, proteolytic processing might generate a wide range of therapeutic peptides with inherent curative properties [31]. The chemical as well as physical resilience of bioactive peptides must be elevated further, and molecular alterations to multifunctional meals could assist in this endeavor.

While the power source bean aroma impedes the nutritional value of food interpreting, legume flour has additionally been used as the primary component of alternatives to meat that are plant-based. [32]. the bean scent comes about by the enzyme-mediated reaction of n-hexane aromatic compounds with alcohol stimulated by the liver enzymes lip in crops. [33]. One technique to reduce the bean aroma is to use alcohols dehydrogenises, which works in order to transform the compounds that make up alcohols into the proper acids. [33]. Utilizing another approach would be to generate meals with enticing aromas, soybean (which lacks lipoxygenase) [34].

III. POTENTIAL EXPECTED FOOD MANUFACTURING TECHNOLOGIES

Food manufacturing future generations is going to be capable to supervise hygiene and safety criteria across the entire food processing process in real time, thanks to significant advances in nanotechnology and artificial intelligence. To produce nutrient-dense food, hygiene surveillance must be swift, simple, and precise. Small sample volumes, higher preference, lower detection limits, and shorter response times are all advantages of enzyme-based biosensors; they require immediate attention for point-of-care food analysis. [35]. Up until now, biosensors powered by enzymes were used for determining infectious microorganisms, biotoxins, and additives.These pesticides and nutritional ingredients.

Table 1: Application of Enzymes in Food Processing.(Reference No. (79)

Enzyme property	Enzyme	Application	References
Food texture	Chymosin	Hydrolysis of αcasein, β-casein, k- casein, and β-lactoflavin milk solidification.	[65]
	Trypsin	Improvement of the foaming and emulsifying properties of protein	[66]
	Transglutaminase	Improvement of protein gel stiffness,viscosity,and water-holding capacity	[10]
	Lipoxygenase	Carotenoids bleaching and improvement of bread dough rheology	[32]
	Pectinase	Improvement of the juice yield and clarity	[67]
	Protease	Tenderization of meat	[68]
	Lipases	Production of food-grade surfactants	[69]
Food safety	Laccase	Detection of the quality change during the storage of fresh-cut fruits and vegetables	[70]
	β-lactamase	Determination of β-lactam antibiotic.	[71]
	Alkaline urate oxidase	Reduction of food uric acid content under alkaline conditions	[72]
	Organophosphate hydrolase	Deduction of pesticide residues	[73]
Nutritional and flavour	Chymosin	Production of more volatile substances	[65]
	Glucose isomerase	Production of sweeteners	[74]
	Lipase	Improvement of the yogurt flavour	[75]
Customized food	pullulans	Production of functional starch microparticles with reduced digestibility	[76]
	Lactase	Production of low-dosage lactose milk	[77]
	Proteolytic enzymes	Production of bioactive peptides	[78]

Rastislav et al. devised a number of complicated microbiological sensor technologies for the combinatorial analysis of food tests comprising insulin, compounds, and beverages. [36]. A relatively straightforward sensor having along an oblong monoxide detection with nylon threads holding the stuck enzyme amine oxides was used to test the freshness of white fish. [37].The sensor detects biogenic demines well since the oxides remained stable for more than twelve weeks when exposed to 4 degrees Fahrenheit and 12 degree Celsius conditions. Food odors and ripeness have also been identified via enzyme-based biosensors, with an electrochemical biosensor capturing the pheromone androstenone. [38]. Immobilised-hydroxysteroid syntheses as well as a screen-printed charcoal electrode were used to make this biosensor. For application in future food production and quality assurance, biosensors for viruses, mycotoxins, and antibiotics have also been created [39, 40]. An enzyme-linked immunosorbent test (ELISA), which integrates the reactivity among an antigen and a particular antibody with the visible catalysis of catalysts.

Future ELISA-based approaches to alimentary authenticity and control hold a great deal of promise. [41]. to evaluate the quantity of sesame seed residue, Stef and others 42 developed an ELISA test that is sensitive and specific. This test might be utilized as a screening tool for foods for persons with severe allergies. ELISA tests can detect a wide range of food borne diseases, particularly Campylobacter. [43], O157:H7 E. coli. [44], Rod shaped [45], the bacteria salmonella [46], as well as the bacterial infection Staphylococcus aurous [47]. ELISAs are also used to identify toxins in meals, such as toxins known as enter produced by the bacteria E. coli and Candida perfringens. [41, 48]. By integrating modules, enzyme-based food-borne pathogen monitors can be upgraded from a single assay to a multi-array function. [49].

IV. THE POTENTIAL OF MICROBIAL INNOVATION FOR THE FARMING SECTOR

The adaptability of metabolic attributes, the establishment of culinary-grade expressing protein hosts, and optimizing the performance of multi-enzyme systems are all long-standing obstacles to the use of enzyme-based methodologies in the food and beverage industry.

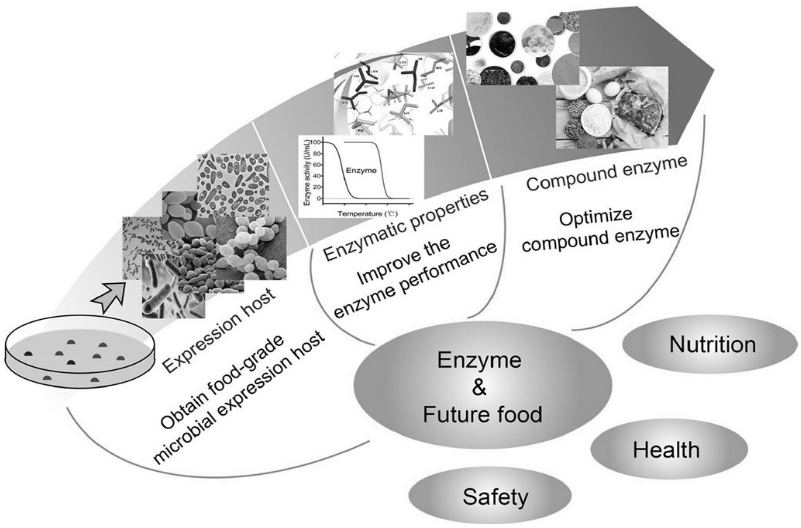

Figure 3: The next phase of protease innovation in meals. (Reference no. (79)

V. ADAPTABILITY OF ENZYMATIC PROPERTIES

Increasing the applicability of catalyst methods for the cultivation of food by improving enzyme activity under specific conditions through protein manipulation. For example, amino acids are required to produce liquor, cellulose, and magnesium glutamate, while its activity is hampered by the acidic conditions in which these activities take place. [50] Ding as well as company. It was feasible to extract a variant of amino acid a species bacteria called Bacillus licheniformis with higher acid tolerance at a pH of 4.5 and a 14-fold boost to catalytic yield (kc at/Km) beyond the native type via controlled evolutionary.

Enhancing chemical modification can also help enzymes adapt better to the industrial setting. Despite this technique has a likelihood for lowering enzyme activity, cell-polymer the bonds might enhance substrate durability. [51]. Promising In order to improve catalytic efficiency and identify the crucial residues involved in catalysis, natural enzymes are frequently changed. The unique activity and catalytic performance of the fibrinolytic gene identified as Sarmatia marcescens partially syn. amanuensis was increased by 19-fold and 219-fold, respectively, by Anshan [52] using amino acid modifiers. These fibrinolytic enzymes' structural analyses revealed modifications to their ß-sheet and -helix conformations. Additionally, enzymes can be chemically altered to enhance enzyme immobilization [53, 54]. The processes that are most prevalent in regard to this are hydrophilization, cat ionization, while unionization and enhancements to the enzyme's properties range from greater cellular penetrability to increased stability or activity. [55].

Advances in the makeup of proteins resources and computational biology have also facilitated the invention of secure, focused, and extremely active enzymes that initiate complex processes in silicon. [56]. Gideon assembled this enzyme and lactones gene families along with remarked on the refinement of their amine sequences using the Rosetta computational system. [57]. Despite having just 25% sequence homology, 21 GH10, and 7 PLL designs are active among these optimized variations. In summary, being able to manipulate food enzymes by cognitive and semi-rational layout, high-throughput screening, and emerging technologies such as machine learning will be critical to subsequent advances in alimentary protease.

VI. IMPLEMENTING AN ALIMENTARY TRANSLATION NETWORK

Food-grade creation of protein requires secure hosts and antibiotic-free genetic procedures; however the method for variant adaptation is hampered by the limited number of hosts accessible. To identify enzymes that are secure for upcoming food processing, food-grade protein expression platforms must be developed.Through generating dual-host (shuttle) gene expression vectors with removable pick indicators for replication in E. These obstacles have been overcome in the edible lactic acid microbes and downstream protein expression. [58], including Lactococcus lactic, Lactobacillus, Bacillus subtitles, Aspergillums Niger, Aspergillums oryzae, and B. licheniformis. Douglas et al. inserted the -galactosidase gene into the L. microsatellite bacteria. In the dairy industry, regenerated lactic acid bacteria are used to boost the efficiency of galactose absorption (as a result, lactose-free milk), which improves the capacity of the human body to absorb and use dairy. [59]. Prolyl amino peptidase has been isolated in bacterium A by Watanabe et al. orchids for their extremely specificity and tolerance to salts, particularly serves as a catalyst in the fermentation process. [60].

To create novel manifestation sections with efficient expression levels, alternative safe for consumption expression hosts are still required. To build the metabolic and regulatory aspects and improve the diet hygiene conveying framework for foreseeable food production, biology and sanitary datasets may be screened using computational biology and system capabilities. In the meantime, illustrating strain features across the mechanism and expression system requires assembling numerous cellular parts into a new-molecule synthesis approach.

VII. MULTI-ENZYME ENHANCEMENT OF THE SYSTEM

Overall multi-enzyme system has evolved into a formidable tool in food production by combining several performing enzymes with each other to increase the reaction rate simultaneously. Ginseng hardness may be greatly decreased following treatment with both neutral proteases and animal proteolytic enzymes, according to Zhou et al. [61]. Li et al. [62] through bringing together several functional digestive enzymes to quicken up their response rate synergistically, the multi-enzyme platform has gradually evolved into a powerful weapon in the cultivation of food. The paper's authors were Zhou and colleagues. [61], both neutral proteases and animal proteolytic enzymes have the potential to significantly reduce the hardness of ginseng. Cited after Li et al. The amount and mix of numerous high-quality enzymes, determined by (DuPont, Rochester, New York, New York City, USA), can improve the handling of food through synergistic effects. Proteins extracted from plants can also be decomposed enzymatic ally (using amino acids like papa in, which is brome lain and and quercetin) followed by treatment with transglutaminase to generate high-quality hydrolysates with increased functional properties such as emulsifying and bubbling abilities. [64].To increase the use of multi-enzyme systems in food production, it will be necessary to: (1) pursuit find high-performing digestive enzymes; (2) tune the enzyme/strain composite system for best yield and performance; and (3) Create a sturdy system that can handle an array of pH levels and temperature settings in workplaces.

VIII. CONCLUSION

The urgent needs of human civilization cannot now be fully met by conventional food production. To face both the financial and environmental challenges of scheduled difficulties with development, the dietary market will need to produce more efficiently, ecologically friendly, and consistently. Future food consumption will change to fit each person's dietary and spiritual requirements and to meet the need for wholesome, Foods that are wholesome and delectable while also enhancing food processing. Considering folks crave bespoke nutrition, subsequent food fabrication is expected to depend on the use of enzymes to create tailored diets. The effectiveness of robust enzymes in enhancing human health has previously been demonstrated by advanced enzyme design technologies. Above foremost, enzyme-based innovations will not merely expand the array of meals available in the future, but also boost the quality of food to meet expanding demand while yielding phenomenal revenue streams to the agricultural industry.

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