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THE ROLES OF ENZYME IN FOOD PROCESSING - AN OVERVIEW

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ABSTRACT

Enzymes haven used long in food processing before their discovery as a biological catalyst. Food fermentation was among the early art of food processing and the use of enzymes in fermentation and cheese making started about 6000 BC. The roles of enzymes in food processing and preservation contributed to the development of mankind. They contributed in the areas of baking, cheese making, dairy processing, milling, cereals technology, juice and beverages processing, vegetable processing, oils and fats processing, and wine processing among others. Microorganisms are the earliest and foremost source of enzymes used in food processing, other sources are plant and animal tissues and organs. Advances in science and technology disclosed more potentials of enzymes and biotechnology open doors for commercial production of enzymes with charming properties. The development of enzyme immobilization techniques allows the reused of enzymes without affecting their properties, structure, or activities. Recent advances in genetic engineering and recombinant DNA technology permit the production of enzymes with exceptional properties. The current trends in the production of Extremozymes will open doors for using enzymes under extreme conditions of temperature, pH, and pressure. In food, processing enzymes can be used as ingredients, processing aid, or as a catalyst for both pre-and post-consumption catalysis. Enzymes improve the quality, shelf life, stability, and sensory properties of foods. They play important roles in food processing by lowering energy consumption, minimizing waste, producing desired products specifically required, and making foods more affordable, palatable, and available.

Keywords: Food, Food Processing, Enzymes, Food Enzymes.

INTRODUCTION

The word "enzyme" was first used by Wilhelm Friedrich Kuhne in 1877, it comes from Greek which means "in leaven" (Kaur and Gill, 2019). Enzymes are catalysts of biological origin with amazing properties and exciting functions produce by all living organisms to regulate biochemical processes (Singhal *et al.,* 2018). The use of enzymes in fermentation and cheese making started around 6000 BC. Enzymes such as pectinase and invertase are in used by food industries since the 1930s (Singhal *et al.,* 2018). Industrial application of enzymes started with the application of chymosin, extracted from the calf stomach in the production of cheese (Ravindran and Jaiswal, 2018). The enzyme industry is among the promising and fast-developing industries, the world enzyme market was estimated at $ 5.5 billion 2 years ago (Kocabaş and Grumet, 2019) and it is expected to reach $ 17.5 billion by 2024 (Cacicedo *et al.,* 2019). Enzymes are efficient and specific in their activities and can alter conventional food processing (Rastogi and Bhatia, 2018; Zhang *et al.,* 2018). They are used in a wide range of food processing including winemaking, baking, cheese making, dairy, milling and cereal processing, juice and beverages, vegetable processing, oils, and fats processing, etc. (Al-Maqtari *et al.,* 2019).

Advances in technology enable rapid development in the enzyme industry. Ability to identify and characterize enzyme from natural resources and technological development that permits modification and purification of the enzyme account for the development in the enzyme industry (Ravindran and Jaiswal, 2018). The emergence of biotechnology opens doors for commercial production enzymes and their use in food industries (Singhal *et al.,* 2018). Metabolically engineered whole-cell are also favourable and can have a bright future (Ravindran and Jaiswal, 2018).

Like a chemical catalyst, enzymes speed up the rate of a chemical reaction by lowering the activation energy. A molecule upon which an enzyme acted is called a substrate, this is converted to an entirely different product at the end of the enzymic reaction (Palit, 2018). Enzymes can initiate and/or accelerates the rate of biochemical reaction but will not be consumed by the reaction. Enzymes are very effective and can breakdown complex heterogeneous materials into simpler material within a short time. For example, carbohydrates, protein, and fat in food can be broken down into their constituents with 3-6 hours by enzymes depending on the type and quantity of the food. However, this process may require more than 30 years to be completed without enzymes. Enzymes are more specific and possess higher catalysis than chemical catalysts and can be reused and recycle when they are immobilized (Kuddus, 2019). Most of the enzymes are used as processing aids with very few such as lysozyme and invertase, are considered as additives (Singhal *et al.,* 2018).

Enzymes commonly used in baking are amylase, maltogenic α-amylase, xylanase, lipase, glucose oxidase, transglutaminase, novamyl, and mylase. While invertase and glucose isomerase are commonly used in confectionery processing. Acid proteinase, neutral proteinase, lipase, lactase, aminopeptidase, catalase, transglutaminase, and peptidase are used in dairy processing. Pectinase, glucose oxidase, α-amylase, β-amylase, protease, pullulanase, naringinase, limoninase, aminopeptidases, A-acetolactate decarboxylase, glucose isomerase, and invertase are used in beverage processing. Cellulase, hemicellulase, pectinase, and protease are used in the extraction and processing of oils and fats (Srivastava, 2019). Lipases used in fat and oil-related foods also play important roles in the processing of fruit juices, baked foods, vegetable fermentation, and dairy enrichment. Proteases contribute to the processing of protein-related food, the enzymes convert complex proteins into peptides and amino acids (Singhal *et al.,* 2018)

Sources of Food Enzymes

Food processing enzymes include artificially added as a processing aid and native enzymes naturally occurred in the food (Zhang *et al.,* 2020). Microorganisms, plant and animal tissues, and organs are the main sources for enzymes used in food processing (Kuddus, 2019; Singhal *et al.,* 2018). Microorganisms are the earliest recognized source and remain the most foremost and potential source (Bilal and Iqbal, 2019a; Ravindran and Jaiswal, 2018; Singhal *et al.,* 2018; Srivastava, 2019). Enzymes are also extracted from the stomach of lamb, calve, young goat, and some plant materials (Al-Maqtari *et al.,* 2019). Some enzymes are only found in plant sources, for example, papain in papaya and bromelain in pineapple (Al-Maqtari *et al.,* 2019). Microbial source gained more attention because it is economically more favourable and effective, cost-efficient, more flexible, and provide higher yield during processing (Espejo, 2020). Enzymes from microorganisms can satisfy the huge demand for food processing industries in the areas of baking, dairy, beverage, confectionery, fruit and vegetable, and meat-processing industries (Srivastava, 2019). Wide varieties of enzymes used in food industries are produced by limited genera of microorganisms, viz. *Bacillus, Aspergillus, Kluyveromyces, Trichoderma, Rhizopus, Saccharomyces*, etc. (Ravindran and Jaiswal, 2018). Examples of enzyme-rich foods are papaya, pineapple, banana, figs, and bee pollen, the common enzymes found in these foods are proteinases, amylases, maltases, lipases, papain, bromelain, etc. These enzymes decrease the body's burden in the production of its enzymes (Ahmad *et al.,* 2018). Certain enzyme-rich foods contain some specific enzyme with functions different from that of indigenous body enzymes. Enzymes with high specificity, less energy consumption, and attractive applications in foods were developed in recent years (Binod *et al.,* 2019). Nanotechnology is the recently discovered source of food processing enzymes, the technology is still under development and is associated with many obstacles and challenges (Zhang *et al.,* 2021).

Development in biotechnology increased the utilization of industrial enzymes and expand the market for industrial enzymes (Kaur and Gill, 2019). Most of the biotechnology applications are related to microorganisms. Microbial enzymes are more interested to researchers because of the ease in their production, gene modification, and diverse catalytic activities (Binod *et al.,* 2019). As the most suitable source for commercial production, the microbial source accounts for more than 90 % of enzymes produced for industrial use. Enzymes from plant and animal origins are in small amounts, difficult to extract and purify, and can be contaminated (Al-Maqtari *et al.,* 2019). Enzymes sourced from microorganisms are safe, they contain no viruses or toxins which are found in animal sources (Gomes *et al.,* 2018), they are also more stable when compare with plant and animal enzymes (Raveendran *et al.,* 2018). The most important advantage of purified enzymes is their catalytic quality which is superior to that of free enzymes which possess poor qualities such as low stability and slow activities under certain conditions and inactivation at higher substrate or product concentrations (Cacicedo *et al.,* 2019).

Development in genetic modification allowed the production of industrial enzymes in large quantities without much constraint (Al-Maqtari *et al.,* 2019). Enzymes produced by plants and animals can now be produced by microorganisms through recombinant DNA technology. The enzymes are produced by fermentation using microorganisms usually bacteria and fungi under careful controlled settings (Palit, 2018). Fermentation is a natural biochemical process that converts renewable substrates into valuable products such as enzymes, organic acid, alcohol, and more. The microorganisms utilized the carbon source in the growth medium and produce enzymes either intracellular or extracellular (Al-Maqtari *et al.,* 2019).

The genus, species, and strain name or code of any organism used for industrial enzyme production must be identified. Understanding the toxigenicity and pathogenicity of the strain is very necessary. The strain to be assessed must be deposited with an internationally recognized culture centre certified by International Depositary Authority. Whole-genome sequence analysis including chromosome(s) and extrachromosomal genetic elements (e.g. plasmids) is required for the characterization of the microorganism (Silano *et al.,* 2019). Also, understanding optimum growth requirements for fermentation microorganisms is important because the nature and composition of fermentation products depend on the microbial strain and fermentation conditions (pH, temperature, and dissolved oxygen) (Al-Maqtari *et al.,* 2019).

Most of the microbial strains used in the production of industrial enzymes are the strain employed by food processors for many years and those identified through mutation and selection. These organisms are genetically modified to overproduced desired enzymes with no production of undesired enzymes (Palit, 2018). Industrial enzymes are obtained from microorganisms by submerged or solid-state fermentation. This follows by cell disruption and filtration. The pure enzyme is obtained by precipitation and centrifugation (Ravindran and Jaiswal, 2018). Submerged fermentation is growing microorganisms in a liquid medium while solid-state fermentation involves growing organisms in a solid medium (Raveendran *et al.,* 2018). Submerge fermentation is preferable because of its higher yield and fewer chances of contamination (Kaur and Gill, 2019). The optimum requirement for pH, temperature, oxygen supply and substrate must be maintained during fermentation for rapid growth and enzyme production (Kaur and Gill, 2019). Enzyme recovery and purification are achieved through the downstream processing method (Al-Maqtari *et al.,* 2019). In solid-state fermentation isolation of enzymes involve disruption of cells if the products are intracellular, filtration (using 0.02-10 µm membranes) to remove solids and concentration. Isolation in submerged fermentation involves cell separation, filtration, and concentration. Separation techniques such as centrifugation, flocculation, filtration, and aqueous two-phase separation such as chromatography, and crystallization are used for isolation and purification of enzymes (Mukherjee, 2019).

The use of Enzymes in Food Processing

Enzymes contributed to the development of mankind due to their applications in food processing. The contribution of enzymes in food processing dated back to ancient times. Enzymes haven used long before their discovery as biological catalysts. The use of papaya to tenderized meat was practice by natives of some Pacific islands and was among the initial application of enzymes in food processing (Gomes *et al.,* 2018). Food fermentation was among the early art of food processing, the process converts raw foods into highly delicious foods with attractive tastes and flavours. Production of food products such as yogurt, bread, wine, beer, etc. requires enzymes. Enzymes produced by some microorganisms can stabilize the acidity and pH of the food matrix and provide optimum growth conditions for fermentation organisms (Lazo-Vélez *et al.,* 2018). Enzymes play important roles in food processing by lowering energy consumption, minimizing waste, producing desired products specifically required, and making foods more affordable, palatable, and available (Kuddus, 2019). In food processing, enzymes are used as a preservative to extend self-life, as a catalyst to convert raw materials into products, as processing aids to modify texture and properties, as an ingredient in the production of pre-digested foods, and as an ingredient for post-consumption catalysis (Kaur and Gill, 2019). Most of the microbial enzymes provide by nature are used in food processing to improve quality, shelf life, stability, and sensory properties (Kaur and Gill, 2019). About 30 % of commercially produced enzymes are used in food processing (Ahlawat *et al.,* 2018). In general, enzymes are used in food processing and in improving nutrition by making food nutrients more available for assimilation and utilization during metabolism (Kaur and Gill, 2019).

Enzymes from microorganisms are used in food preparation to improve desirable attributes such as texture, colour, stability, nutritional qualities (Copetti, 2019), taste and flavour, they also offer huge economic benefits to producers (Raveendran *et al.,* 2018). Presently, almost all food processing required enzymes. Examples of processing required enzymes are the production of syrups, sweeteners, chocolates, infant foods, bakery products, alcoholic beverages, cheese, and dairy products, egg products, fruit juice, soft drinks, candy, flavour development, meat tenderization, etc. (Kuddus, 2019). The use of various food enzymes is necessary because of the rapidly growing world population (Taheri-Kafrani *et al.,* 2020) and the rising demand for new foods with improved qualities and ease of preparation (Binod *et al.,* 2019). The development of new enzymes through biotechnology at a lower cost and the discovery of new application fields will widen the enzyme industry soon (Singh *et al.,* 2019).

Enzymes favor many processing operations and can be used as additives, ingredients, or processing aid that can enhance nutritional value, sensory and keeping qualities (Joseph *et al.,* 2019). Enzymes are an important tool for modifying the physical and chemical properties of food materials (Wu *et al.,* 2020), improving sensory qualities, shelf life, and overall quality of the processed food (Bilal and Iqbal, 2019a). Gharibzahedi *et al.* (2018) reported the production of complex and firmer protein gel with denser crosslinking and superior physicochemical qualities by a combination of enzyme treatment using microbial transglutaminase and novel processing techniques. Enzyme-modified cheese with unique sensory attributes was developed by Bas *et al.* (2019) using proteolytic enzymes. Many foods with different chemical and rheological properties are developed and understanding their digestive properties is also important (Garcia-Campayo *et al.,* 2018).

Enzymes are used as important indicators for maintaining the standard in food processing. The ability of a substrate to be converted into products can be determined by studying enzyme concentration in the growth media. Enzymes inhibitors can be determined by comparing enzyme concentration and substrate conversion rate. In addition, enzymes can be used as an indicator in milk pasteurization, vegetable blanching, can be used in combination with biosensors to detect quality changes and freshness during processing and smart packaging (K. Kaur and Kaushal, 2019)

Enzymes add value to foodstuffs and immensely contributed to good health by breaking down complex food components and by the elimination of anti-nutrients (Møller and Svensson, 2021). Enzyme technology has many potentials in solving problems associated with digestion complications in humans such as allergies, absorption problems, and contaminations (Vandenberghe *et al.,* 2019). Germination and fermentation improve plant protein digestibility (Sá *et al.,* 2019). Allergies associated with enzyme deficiency can be controlled by supplementing foods with the required amount of deficient enzymes. This can be beneficial to individuals with lactose intolerance, gluten intolerance, poor digestion of vegetable oligosaccharides, and other digestion problems (Binod *et al.,* 2019; Vandenberghe *et al.,* 2019). Production of functional foods enrich with gastro microorganism or their enzymes can correct gut dysbiosis, rejuvenate and enrich beneficial gut microorganisms. The incorporation of certain enzymes into processed food that can catalyzed degradation of anti-nutrients such as phytate can improve nutrients absorption (Binod *et al.,* 2019). The discovery of new sources of foods with industrial potentials requires the attention of enzymologists, for example, the recent discovery of gums from seaweed that can be used as a food stabilizer, and for medical used as antithrombotic and anticoagulant (Binod *et al.,* 2019).

Extreme processing of foods destroys natural food enzymes and leaves the body deprived of these important enzymes which function in maintaining good health. Many processing techniques, including novel ones, affect enzyme properties and catalytic actions, Han *et al.* (2019) reported the effects of cold-plasma treatment on enzyme activities. Similarly, electrotechnologies used for non-thermal preservation can influence enzyme activities by changing their conformation and structure (Kostelac *et al.,* 2020). Non-electronic non-thermal treatments such as high-pressure carbon dioxide and high hydrostatic pressure treatments also affect enzyme activities (Iqbal *et al.,* 2019).

Biotechnology is now the innovative tool for supplying food enzymes with desired characteristics at an affordable cost. The technology is also solving problems related to processing, safety, and waste management. Enzyme hydrolysis is a promising technique for converting food wastes into valuable and useful materials (Shen *et al.,* 2019). Rivero-Pino *et al.* (2020) recommended the use of sardine-waste hydrolysate, obtained by enzyme hydrolysis, as an ingredient for food processing. Many bioactive compounds, prebiotics, biofuels, biodegradable plastics, rare sugars, sweeteners, surfactants, and other essential products can be obtained from food wastes by enzyme-derived valorization (Bilal and Iqbal, 2019b).

Enzymes can be immobilized by fixing them to inert, nontoxic, and insoluble carries (Yushkova *et al.,* 2019), this allows them to work in a non-native and punitive environment that permits their reuse and recycling (Cacicedo *et al.,* 2019). Enzymes immobilization improves enzyme stability and activity, lowers their production cost (Taheri-Kafrani *et al.,* 2020), and avoids the presence of potential allergens from the enzyme residues (Espejo, 2020).

Genetically Modified Enzymes

Most of the enzymes used in food processing are produced through recombinant DNA technology (Kocabaş and Grumet, 2019). Genes modification through genetic engineering and recombinant DNA technology is a potential method for improving the quality and productivity of microorganisms. Genes of an organism are altered to impart desirable quality so that the organism will excel in that particular quality. Organisms that undergo gene modification are called genetically modified organisms GMOs (Verma *et al.,* 2019). The development in genetics and processing engineering enables the productions of enzymes with improved properties at a lower cost (Palit, 2018). Gene modification requires comprehensive understanding and integration of bioinformatics, enzymology, biophysical chemistry, molecular biology (Zhang *et al.,* 2019), genetic engineering application, fermentation technology, and process optimization (Srivastava, 2019).

The main aim of gene modification is to produce enzymes that a stable under different processing conditions, efficient, very specific in action and can be easily controlled during processing (Zhang *et al.,* 2018). Because the current trend in food processing required precision in processing conditions and foods are exposed to extreme conditions such as high temperature, high pressure, high salinity, high pH, and other conditions that cannot be tolerated by the natural enzymes. Genes modification is used to alter enzymological properties and improved the efficiency of natural food enzymes to curtail their inefficiency under these sophisticated and extreme processing conditions (Zhang *et al.,* 2019). Discoveries in recombinant DNA technology allow the production of smarter enzymes that are specifically required for a process and suppressed the limitations associated with indigenous enzymes in foods. The technology also exposed possibilities for the production of enzymes that were initially very difficult to handle (Srivastava, 2019). Enzymes with improved properties that can function optimally at extreme temperatures were developed through metagenomics, recombinant DNA, and protein engineering techniques. For instant, cold-active enzymes can efficiently catalyze reactions under refrigeration and freezing conditions, and heat-stable enzymes can be active at a temperature above 100 °C. Examples of these novel enzymes with improved catalytic properties include proteases, glycoside hydrolases, lipases, and transglutaminases (Zhang *et al.,* 2018).

Enzymes produced by GMOs are more economical, they are cleaner, and are more amenable during processes (Verma *et al.,* 2019). Despite the safety challenges of the presence of bacterial toxins and mycotoxins, genetically modified enzymes are promising source with high potentials to producers, consumers, and the environment (Zhang *et al.,* 2019).

Food regulatory bodies are very concerned about the safety of enzymes extract from GMOs. Production of enzymes from GMOs is regulated by the Joint Food and Agriculture Organization of the United Nations/World Health Organization Expert Committee on Food Additives (Kocabaş and Grumet, 2019). Many enzymes used by food industries with exceptional properties are from GMOs. These enzymes have wide application in cereal milling and baking, egg-based products, and beverage and dairy processing. Examples of available enzymes from GMOs are α-amylase, α-acetolactate decarboxylase, aminopeptidase, arabinofuranosidase, β-glucanase, catalase, chymosin, cyclodextrin glucosyltransferase, glucoamylase, glucose isomerase, glucose oxidase, hemicellulase, triacylglycerol lipase, maltogenic amylase, pectinlyase, pectinesterase, polygalacturonase, phospholipase, phytase, protease, pullulanase, xylanase and many more (Verma *et al.,* 2019).

Extremophiles and Extremozymes

Most of the enzymes used in foods are active at ambient temperature (25–37 °C), they lost their activity at elevated temperature and become less active at a lower temperature. The need for enzymes with specific properties and that are potentially active under various processing conditions boosted the search for organisms with distinct properties (Khan and Sathya, 2018). One of the major hurdles in industrial processing using enzymes is their instability at extreme processing conditions (Sharma *et al.,* 2019). Microorganisms are integral parts of the ecosystem, they are very ubiquitous and survive in diverse and extreme environments (Ahlawat *et al.,* 2018). Extremophiles are microorganisms that can exist and successfully survive in a variety of extreme conditions including temperature, pH, heavy metals, and salinity (Akanbi *et al.,* 2020), they are classified into thermophiles, hyperthermophiles, halophiles, psychrophiles, piezophiles, and alkalophiles. These organisms can produce enzymes that can exert catalysis at these extreme conditions (Sharma *et al.,* 2019). The enzymes produced by these microorganisms are called extremozymes. The activity of thermostable recombinant β-galactosidase produced from *Pyrococcus woesei* in a wide pH range (4.3–6.6) and higher temperatures allowed the processing of milk at a condition that restricts microbial growth (Synowiecki *et al.,* 2006). Psychrophilic β-galactosidase is also available and allows dairy processing at < 15 °C (Xavier *et al.,* 2018). Kim *et al.* (2020) recently discovered fibrinolytic enzymes that can function at a wide pH range (5.0 to 10.5). Alvarez *et al.* (2020) discovered cold-adapted transglutaminases that are active over a wide range of temperatures (0 to 65 °C). The application of extremozymes in toxins and polymers degradation was also reported by Akanbi *et al.* (2020). Extremophilic enzymes have similar structural conformity with mesophilic enzymes but vary in their response to extreme conditions.

Thermostable Enzymes (Thermozymes)

Thermostable enzymes are enzymes that possess catalysis at higher temperatures. These enzymes play an important role in long time processing by eliminating contamination from adapting microorganisms and enzymes that originated from food materials during processing (Synowiecki *et al.,* 2006). The presence of thermostable proteins with additional hydrogen bonds and higher hydrophobic interaction and rigid and stronger cell walls and membrane account for the thermal stability of thermozymes (Sharma *et al.,* 2019)

The advantage of thermostable enzymes is that when used in high-temperature processing, their activities can be arrested by cooling to ambient temperature. The application of these enzymes also eliminates dangers that can cause by microorganisms during ambient processing. Higher solubility and decrease viscosity are observed at higher temperatures, the earlier will improve substrates utilization and the latter will improve mixing and pumping in a continuous process operation (Synowiecki *et al.,* 2006). Other advantages are higher storage stability, increased reaction rate and catalytic activity, improved mass transfer during reactions, resistance to organic solvent, and resistance to chemical denaturation (Sharma *et al.,* 2019). The major disadvantage of using these enzymes is that most thermophilic bacteria produced a small amount of enzymes, also, higher energy consumption and rapid corrosion of processing equipment particularly if corrosive materials are parts of the products (Synowiecki *et al.,* 2006).

The major sources of thermozymes are thermophilic and hyper-thermophilic bacteria and archaeal species (Sharma *et al.,* 2019). Thermophilic organisms such as *Pyrococcus woesei, Clostridium thermosaccharolyticum, Clostridium thermohydrosulphuricum, Thermus thermophiles, Thermococcus hydrothermalis* and *Pyrococcus furiosus* (Synowiecki *et al.,* 2006), *Geobacillus, Alyciclobacillus*, and *Anoxybacillus* (Atalah *et al.,* 2019) are used in the production of thermostable enzymes such as α-amylase, α-glucosidase, β-galactosidases.

Cold-Active Enzymes

Psychrophilic organisms including bacteria, mold, and yeast are capable of producing cold-active enzymes that can endure low-temperature treatment. These microorganisms are capable of producing a wide range of enzymes that can be active during cooling and freezing operations. The latest applications of cold-active enzymes are the use of β-galactosidase for removal of lactose in refrigerated milk, and the use of pectinase to lower viscosity and turbidity of chilled fruit juice (Hamid and Mohiddin, 2018). Cold-active enzymes also known as psychrophilic enzymes possess higher catalytic activities at moderate and lower temperatures. They utilized a low amount of energy and maintained labile compounds in the reaction medium, and their inactivation required little heat input. It is expected that the applications of these enzymes will be more than that of thermostable enzymes due to their energy consumption pattern. They will have desirable applications in the processing of milk, meat, juices, and baking to reduce fermentation time and retain flavours (Kuddus, 2018). They can be used for ambient processing in arctic regions of the world. These enzymes withstand low temperature and have mechanisms that prevent their deactivation by low temperatures (Joseph *et al.,* 2019).

The sources of these enzymes are essentially psychrophilic organisms living in arctic regions of the world; including polar zones, glaciers, tall mountains, and deep oceans. These including fishes and microorganisms that possess optimum growth activities at lower temperatures. The enzymes are very rare at present and their application in biotechnology and food processing is also not very common (Kuddus, 2018).

Low thermal stability and high isolation and purification cost are among the major challenge that will limit the utilization of cold-active enzymes. The application of recombinant DNA technology to improve their adaption to a wider range of temperatures will increase their utilization (Kuddus, 2018). The production of Psychrophilic enzymes is an emerging area in food processing with very few achievements, it's expected to attain notable success in years to come (Joseph *et al.,* 2019).

CONCLUSION

Microorganisms, plant and animal tissues, and organs are the main sources of enzymes used in food processing. Enzymes are very effective and can breakdown complex heterogeneous materials into simpler material within a short time. Enzymes can initiate and/or accelerates the rate of biochemical reaction but will not be consumed by the reaction. Technological advancement in the area of microbiology, genetic engineering, recombinant DNA technology, and food processing opens doors for use in almost all areas of food processing. Their use in food is now beyond catabolism and flavour development. Enzymes with unique and desired properties are produced through industrial processes. They are engineered to catalyse only desirable reactions and produced only desired products. Enzymes with high specificity, less energy consumption, and attractive applications in foods were developed in recent years. In addition to their use as a processing aid, they also play important roles in improving qualities, shelf life, stability, and sensory properties. They also have special functions in converting food wastes into valuable and useful materials. They are required They are used in a wide range of food processing including baking, cheese making, dairy processing, milling, cereals technology, juice and beverages processing, vegetable processing, oils and fats processing, winemaking, production of syrups, sweeteners, chocolates, infant foods, egg products, soft drinks, candy, flavour development, and meat tenderization among others. With the discovery of extremozymes, processing conditions are no longer a barrier to their application in foods.

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