APPLICATION OF IMMOBILIZED ENZYMES IN FOOD TECHNOLOGY INDUSTRY

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Abstract: Enzymes found in living organisms accelerate a wide range of chemical and biological reactions. The lack of long-term working stability, shelf-life, and challenging recovery and reusability limit all of enzymes' promising applications in the food sector. The enzyme must be immobilized using an encapsulating technique to overcome this disadvantage. Carrier components for the encapsulation process, such as carbohydrates, protein, and lipid-based encapsulation, must be carefully chosen. Therefore, different support materials have varying degrees of influence on immobilized enzyme activity. Support materials for immobilizing enzymes must satisfy the enzymes' needs while also being sturdy enough to withstand the enzymatic processes' circumstances. The goals of this research are to discover new immobilized enzymes and to determine the role of immobilized enzymes in the baking, sugar, juice, and dairy industries. Furthermore, to investigate ways for improving immobilized enzymes by considering immobilization practice and carrier support. Additionally, to determine whether immobilized enzymes would affect the physical and chemical qualities of food, as well as to determine how many times immobilized enzymes have been utilized. The data revealed that different types of supports have a significant impact on the surrounding environment's hydrophilicity or hydrophobicity, altering whether chemicals partition towards or away from the enzyme. This approach is commonly used to stabilize enzymes in the presence of inactivating substances such as organic solvents, hydrogen peroxides, oxygen, and other dissolving gases. The carrier materials were identified to have biodegradability, biocompatibility, multivalent functionalization, good reusability, money savers, unique structural features, and remarkable stabilities. Carrier materials play an important role in enzyme immobilization. Consequently, higher scrutiny of enzyme catalytic performance on a commercial scale may be applied based on new matrices that could improve biocatalytic potentialities, novel enzyme immobilization methods, and advanced functional and innovative materials to fulfil expanding international needs.

Keywords: Encapsulation, carrier materials, encapsulating materials, enzyme immobilization, enzyme reusability

1. Introduction

Enzymes are recognized for their high substrate specificity, which is determined by the substrate's chemical and structural configuration in a certain environmental setting without generating any unwanted by-products. Enzymes are employed in their natural state for the most part. Salts, surfactants, alkalis, and trace amounts of chemicals are more vulnerable to free-form enzymes, which can operate as inhibitors and spiral manufacturing costs. Free-form enzymes can be lost as the reaction advances because of changes in reaction conditions, leading to decreased enzyme

healing from the reaction mixture. Variations in enzyme activity have an impact on product quality and quantity. Because the enzyme synthesis process is relatively expensive, post-reaction healing of enzymes can lower operational expenses. The recovery and reuse of enzymes from the reaction solution, on the other hand, is difficult and expensive (Fabra et al., 2019).

Immobilization of enzymes is a well-known approach for eliminating the drawbacks of employing free enzymes while simultaneously improving the production process' capability and cost-effectiveness. The attachment of enzymes to support material to restrict the movement of molecules, hence decreasing loss and allowing for spontaneous healing with little or no loss of enzyme activity, is known as enzyme immobilization. Immobilization improves enzyme stability against structural deformation and various denaturing organic solvents by engaging the amino acids with activated carrier functional groups. The presence and density of functionalized groups on the enzyme surface impact the immobilization process' ability and the strength of immobilized enzymes in storage and operations. However, because scaling up processes using immobilized enzymes is primarily cost-driven, an economic assessment of the overall process is performed before using an immobilized enzyme, considering all related costs such as a native enzyme, immobilization resin, downstream manufacturing, reactors, immobilized enzyme disposal after use, and carrier regeneration (Bilal & Iqbal, 2019).

2. Discussion

2.1. Gluten free bread

To date, there are no new immobilized enzymes. Most of the researchers used Maltogenic amylase (MAase) or α-amylase in gluten free bread. The encapsulated enzymes help to postpone the staling of gluten-free bread and stabilize the enzymes in acidic medium of batter. To date, encapsulation enzymes in the supporting carrier such as maltodextrin and beeswax are the latest discoveries that help to stabilize the enzymes. Encapsulated MAase-loaded bread showed a darker crust, white and softer crumb, more aerated structure, and higher sensory acceptability. There remains a knowledge deficit in the field of enzyme reusability. Apart from that, the enzyme concentration is not measured during the procedure. This is a critical parameter for measuring the stability of enzymes (Haghighat-Kharazi et al., 2020).

2.2. Dairy industry

Galactosidase is the most common enzyme used in the production of low amounts of lactose in milk. The stabilized enzymes help to catalyze the hydrolysis of lactose efficiently as the free enzyme is easily denatured, and it may not be reused. The encapsulation of lactase in k-carrageenan-based with buffer, alginate-agarose hydrogel, and chitosan with genipin as the cross linker produced a good result in lowering the amount of lactose in milk. The immobilized enzymes did not alter the physical or chemical properties of the food. The immobilized enzymes can be reused 4-10 times in a continuous cycle (Lima et al., 2021).

2.3. Juice industry

To date, only the enzyme pectinase is used in juice clarification. The immobilized pectinase helps to reduce the turbidity in the fruit juice that is caused from hydrocolloid called pectin. The enzymes

were immobilized on Magnetic nanoparticles (MNPs), silanized glass beads with cross linkers, Montmorillonite clay (MC), and chitosan beads. No physical or chemical properties of the juice were altered by the immobilized enzymes (Dal Magro et al., 2021). According to the findings, immobilized enzymes can be reused a minimum of 7 times and a maximum of 10 times.

2.4. High fructose corn syrup (HFCS)

Based on the recent findings, amyloglucosidase and glucose isomerase (GI) were used in producing high fructose corn syrup (HFCS). The immobilized enzyme demonstrated outstanding operational stability in the face of environmental change. Different carriers were used to immobilize the enzymes, including silica/chitosan hybrid, chitosan, and supported cross-linked enzyme aggregates (CLEAs). The physical and chemical qualities of the syrup are not affected by the enzymes. Within three months, the enzymes can be reused 6-15 times (Wahab et al., 2020).

3. Conclusion

While the immobilized enzymes were being introduced to the process, there was no negative impact on the end products. However, enzyme concentration tests, activity of free enzymes under immobilization conditions, and evolution of activity in the supernatant should be performed because the strength of the immobilized enzymes is critical. Moreover, the form of immobilization, cross-link agent, reactor, and carrier employed, should be the first focus before starting the procedure.

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