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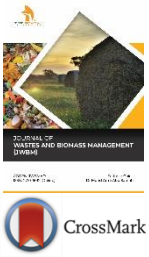

REVIEW ARTICLE

A REVIEW OF FACTORS AFFECTING ENZYMATIC HYDROLYSIS OF FOOD WASTE

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ABSTRACT

Bioconversion of Food waste into bioenergy can be accomplished by enzymatic hydrolysis and fermentation. Food waste containing carbohydrate must be subjected to enzymatic hydrolysis to enhance the digestibility of its polymerisation structure. The three stages involved to produce fermentable sugars are gelatinization, liquefaction, and saccharification. Enzymatic hydrolysis used enzyme alpha-amylase to break down carbohydrate that contained in the food waste into simple sugars. The simple sugars are converted to various bio-chemicals by a process of fermentation.

In this review, the effects of various factors on enzymatic hydrolysis have been thoroughly studied. It has been discussed how various substrate and hydrolysis conditions affect the rate of enzymatic hydrolysis of food waste. There is also some strategies applied to overcome the presence of inhibitors that effect the hydrolysis to yield maximum amount of fermentable sugars.

KEYWORDS

Enzymatic hydrolysis, gelatinization, liquefaction, saccharification, food waste.

1. INTRODUCTION

Food waste is a biodegradable waste that is emitted from a variety of sources, including homes, households, and the hospitality industry. Nearly 1.3 billion tonnes of food, including fresh fruits, vegetables, meat, bakery goods, and dairy products, are lost along the food supply chain, according to FAO. According to projections, there will be more food wasted in the next 25 years as a result of population and economic growth, particularly in Asian nations. According to reports, between 2005 and 2025, the amount of urban food waste in Asian nations could increase from 278 to 416 million tonnes annually (Paritosh et al., 2017). Food waste impacts the environment in many ways. When the food was dumped to landfills, it started to decompose and releases methane gas into the atmosphere that adversely affects the climate and causes global warming. The land is also wasted where it is used for the agricultural, livestock raising and conserving food that has been discarded (Hawthorne et al., 2017).

Fermentation process needs saccharides and other nutrients contained in the food waste (Hudečková et al., 2017). Anaerobic degradation of molecules like glucose occurs chemically during fermentation (Gregersen et al., 2023). Polysaccharides found in food waste should be hydrolyzed before fermentation. Although the size and morphology of the granules of starch vary depending on the plant species, their internal architecture—which consists of growth rings, blocklets, and crystalline and amorphous lamellae—is strikingly similar. Two polyglucans, amylose and amylopectin, are the fundamental elements of starch granules. Since amylose is made up of long chains of glucose residues connected by α-(1,4)-linkages and a few α-(1,6)-branches, its molecular structure is comparatively straightforward. The main component, amylopectin, shares the same fundamental structure but has much shorter chains and more α-(1,6)-branches (Bertoft et al., 2017).

Enzymatic processes have largely replaced acid catalysis, which historically hydrolyzed the substance. This is because the former method required the use of corrosion-resistant materials, produced salt ash with a high colour content (after neutralisation), required more energy for heating, and was more difficult to regulate. Liquefaction and saccharification are the two steps in an enzymatic process. The enzyme α-amylase breaks down 1,4-glycosidic bonds in the first step to produce shorter chains of soluble dextrins. In the second, the enzyme glucoamylase attacks 1,4 terminal bonds to release one glucose unit at a time from the degraded molecules. As a result of the incomplete conversion of starch to glucose, the final product typically consists of a mixture of glucose, maltose, and longer-chain sugars. Depending on the kind of enzymes used, the ideal pH, temperature, and other operating conditions vary between the two steps (Betiku et al., 2010).

2. ENZYMATIC HYDROLYSIS OF FOOD WASTE

Acid or an enzyme can be used to hydrolyze starch. When a German chemist named Kirchoff demonstrated that boiling wheat starch with diluted sulfuric acid could produce a sweet syrup, he thus made the discovery of acid hydrolysis. The hydrolysis of starch in the industry has changed over the last few decades from using acid to enzyme. With α-amylase and glucoamylase, which yields 95% more glucose, the acid was largely replaced (Azmi et al., 2017). Over acid hydrolysis, enzyme hydrolysis has a number of benefits. Less energy is needed for enzyme hydrolysis, and the environment is more benign. Compared to acid or alkaline hydrolysis, it is a less corrosive process and is friendly to the environment. Furthermore, enzymatic hydrolysis results in the absence of inhibitory compounds (Amit et al., 2018).

The primary building blocks of amylaceous materials are glucose molecules linked together by links α-1,4 and α-1,6 to form a linear chain called amylose and a branched chain called amylopectine. The native structure of amylaceous materials is composed of granules that are packaged in amorphous and crystalline regions.The natural structure of

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starch is changed during the gelatinization stage, loosening the second structure of the crystalline region and leaching the amorphous region, making the starch more vulnerable to the first enzymatic attack. In the liquefaction stage, the endo-enzyme α-amylase is frequently employed, randomly hydrolyzing the α-1,4 bonds of amylose to produce maltodextrin. Amyloglucosidase, an exo-enzyme that hydrolyzes the α-1,4 and α-1,6 bonds in amylopectin to produce glucose as the main product, is used during the saccharification stage (Acosta-Pavas et al., 2020).

3. Enzyme Inhibition and Enzyme Inhibitors

The reaction rate of the enzymes is wholly or partially inhibited during the process of enzyme inhibition. Enzyme inhibitors are molecules that can completely or partially bind to a target enzyme and inhibit that enzyme's activity. Inorganic or organic, simple or complex molecules make up enzyme inhibitors. They either bind where subtract is already bound or they can block one side when an inhibitor is already bound, preventing subtract from binding with the enzyme. Competitive inhibitors bind to the active site in a competitive manner because they share structural similarities with their rivals and the substrate. Because the allosteric enzyme has an allosteric site on its surface, allosteric inhibition happens. This location is a long way from the enzyme's active site. The combined final end product fits the allosteric site exactly. There is no structural similarity between the inhibitor and the substrate in non-competitive inhibition. Both enzyme-inhibitor (EI) and enzyme-inhibitor-substrate (EIS) complexes are formed when the inhibitors bind to the enzyme at locations other than the substrate binding site (Patadiya et al., 2021).

4. Conclusion

A linear chain called amylose and a branched chain called amylopectin are formed by the joining of starchy materials by links α-1,4 and α-1,6. The complex structure of starch is hydrolyzed by enzymes to produce monosaccharide at the chain's terminus. Gelatinization, liquefaction, and saccharification are the processes that make up enzymatic hydrolysis. For the inhibitors, it can be concluded that reversible inhibitors are preferable to non-reversible inhibitors because the latter can cause toxicity. Because they have no rivals for the binding site, allosteric inhibitors are the most effective inhibitors.

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