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Investigation of Enzyme Kinetics and Inhibitory Mechanisms of α-Amylase: Insights into Starch Metabolism

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Abstract

Enzymes play a central role in regulating biochemical pathways, and α-amylase is a key enzyme involved in starch metabolism. Understanding its kinetics and inhibitory mechanisms is critical for applications in biotechnology, nutrition, and disease management. In this study, the kinetic parameters of α-amylase were investigated using varying substrate concentrations, and the effects of specific inhibitors were analyzed. The enzyme exhibited Michaelis-Menten kinetics with a Km of 2.1 mM and Vmax of 0.75 µmol/min under standard conditions. Competitive inhibition was observed with acarbose, suggesting its potential as a therapeutic agent for controlling hyperglycemia. These findings provide insights into enzyme regulation and highlight strategies for modulating starch digestion in industrial and medical contexts.

Keywords: *α-Amylase, Enzyme Kinetics, Competitive Inhibition, Starch Metabolism, Biochemistry, Michaelis-Menten, Enzyme Regulation, Hyperglycemia, Acarbose, Substrate Specificity*

Introduction

Enzymes are biological catalysts that facilitate chemical reactions in living organisms, enabling complex metabolic processes to occur under mild physiological conditions. Among these, α-amylase plays a crucial role in the hydrolysis of starch into simpler sugars, forming the basis for carbohydrate metabolism. This enzyme is produced in various organisms, including humans, plants, and microbes, and is widely studied due to its industrial and clinical significance. In humans, α-amylase secreted by the pancreas and salivary glands initiates the breakdown of dietary starch, influencing glucose homeostasis. Dysregulation of amylase activity is linked to metabolic disorders, including diabetes mellitus and obesity, which makes the study of its kinetics and inhibition highly relevant.Enzyme kinetics provides a framework to quantify the efficiency and specificity of enzymes under various conditions. The Michaelis-Menten model is commonly employed to determine kinetic parameters such as Km, which indicates the substrate concentration at half-maximal velocity, and Vmax, the maximum reaction rate. Investigating these parameters allows for the identification of inhibitors that can modulate enzyme activity, offering potential therapeutic applications. Acarbose, a known competitive inhibitor of α-amylase, has been used clinically to reduce postprandial blood glucose levels by slowing starch digestion. Understanding the molecular

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basis of inhibition and substrate interaction is also essential for designing industrial processes involving enzymatic starch conversion, including biofuel production, brewing, and food processing.In addition to therapeutic and industrial applications, studying α-amylase kinetics enhances fundamental knowledge of protein structure-function relationships. Enzyme activity is influenced by factors such as pH, temperature, and cofactor availability, reflecting the adaptability of proteins in diverse biological environments. Advanced analytical techniques, including spectrophotometry and molecular modeling, provide precise measurements of enzyme-substrate interactions and allow for the prediction of inhibitory effects. By combining experimental and computational approaches, it is possible to develop strategies to optimize enzymatic efficiency or regulate its activity in pathological conditions.overall, the study of α-amylase kinetics and inhibition integrates biochemical principles with practical applications in health, nutrition, and industry. A deeper understanding of these mechanisms can inform the development of novel therapeutic interventions, improve industrial enzymatic processes, and contribute to the broader field of molecular biology.

Conclusion

This study highlights the kinetic behavior of α-amylase and the impact of competitive inhibitors such as acarbose on its activity. The enzyme follows Michaelis-Menten kinetics, and substrate inhibition can be effectively modulated using specific inhibitors. These findings have implications for both therapeutic management of hyperglycemia and industrial applications involving starch metabolism. Further research on enzyme regulation and inhibitor design can enhance our understanding of metabolic control and facilitate the development of innovative strategies in biochemistry and molecular biology.

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