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Digestion System Processes

Introduction

Three experiments were conducted to investigate a variety of enzymes under different conditions in order to study their effects on digestion of starches, proteins, and fats.

Digestion is accomplished through the process of hydrolysis in order for our bodies to be able to absorb necessary nutrients. The primary goal of digestion is to break down polymers of macromolecules in the foods that are consumed into smaller monomers that our cells can use to build their own polymers and to provide our bodies with energy. Digestion is facilitated by substances called enzymes, which act as catalysts to initiate or increase the rate of reactions such as those involved in digestion.

There are a variety of enzymes found throughout the human body that are necessary to keep the body functioning properly. The three common enzymes involved in digestion are lipase, amylase, and protease. Lipase is an enzyme that breaks down lipids into fatty acids and glycerol, amylase breaks down starches into glucose, and protease breaks down proteins into amino acids. However, changes in temperature outside the preferred range for a particular enzyme denatures the enzyme and renders it useless. When an enzyme is denatured it becomes distorted and it can no longer bind to its substrate or perform its usual functions in the digestive process.

Materials and Methods

In the first experiment, salivary amylase was used to study the hydrolysis of starch into maltose by noting the presence of starch and maltose in the experimental samples. By noting the presence of different components tested, the extent to which enzymatic activity had occurred can be determined. It is important to note that as starch decreases, sugar increases as hydrolysis occurs in the presence of salivary amylase.

In the second experiment, protein digestion was assessed with the use of trypsin, which is converted from trypsinogen in the small intestine. Trypsin is an active protease that acts as a catalyst for other proenzymes that produce chymotrypsin, carboxypeptidase, and elastase. These enzymes break peptide bonds that link specific amino acids and avoid others. The main function of these enzymes is to break down proteins into dipeptides, tripeptides, and amino acids.

The third experiment was performed in order to demonstrate the emulsification action of bile while also assessing the digestion of fats with the enzyme lipase. Bile, although not an enzyme, was used in this experiment due to its important function in the process of fat digestion and for its emulsifying action. Bile helps to break down fat particles into smaller particles, and once emulsified, the fats provide a larger surface area for enzyme activity.

Additional details regarding the specific materials used and the processes followed can be found in Exercise 39 of the referenced lab manual referenced.

Results

Tube #	1A	2A	3A	4A	5A	6A
Additives (3 gtt ea)	Amylase, water	Starch, water	Maltose, water	Amylase boiled, the starch added	Amylase, starch	Amylase, starch
Incubation temp.	37°C	37°C	37°C	37°C	37°C	0°C
IKI test	yellow	blue-black	yellow	blue-black	yellow	blackish
Result	-	+	-	+	-	partial +
Benedict's test	blue	blue	orange	blue	green	orangish-yellow
Result	--	-	=	-	=	partial +

Table 1: Salivary Amylase Digestion of Starch

Tube #	1T	2T	3T	4T	5T
Additives (3 gtt ea)	Trypsin, water	BAPNA, water	Boiled trypsin, BAPNA	Trypsin, BPNA	Trypsin, BPNA
Incubation temp.	37°C	37°C	37°C	37°C	0°C
Color Change	clear	clear	clear	yellow	clear
Result	**-**	**-**	**-**	**+**	**-**

Table 2: Trypsin Digestion of Protein

Tube #	1L	2L	3L	4L	5L	4B	5B
Additives (3 gtt ea)	Pancreatin, water	Litmus cream, water	Boiled pancreatin, litmus cream	Pancreatin, litmus cream	Pancreatin, litmus cream	Pancreatin, litmus cream, bile salts	Pancreatin, litmus cream, bile salts
Incubation temp.	37°C	37°C	37°C	37°C	0°C	37°C	0°C
Color Change	no change	blue	blue	pink	blue	reddish	blue
Result	-	-	-	+	-	+	-

Table 3: Pancreatic Lipase Digestion of Fats

Discussion and Conclusion

From the results in Table 1 it can be seen that the control test tubes (1A, 2A, and 3A) display the expected colors. Since the iodine solution reacts with starch there was no color change for the amylase/water and maltose/water samples leaving them the yellow color of the reagent, but there was a reaction with the starch/water sample resulting in a deep blue-black color change. Additionally, since boiling the amylase in tube 4A denatures the amylase enzyme, when starch was added after boiling the iodine reagent reacted with the starch and the contents of the tube turned blue-black. However, when the amylase was not boiled, the enzyme was able to hydrolyze the starch into glucose and the iodine did not react to the starch, which left the test tube contents yellow. Finally, test tube 6A was incubated at 0°C, which slowed hydrolysis and also rendered the process incomplete resulting in a black color that was not as deep as the conditions incubated at 37°C. It can also be seen from table 1 that there was a

reaction to the sugars maltose (3A) and the hydrolyzed glucose (5A), as well as a partial reaction to the amylase/starch solution incubated at 0°C.

As expected the data from Table 2 show no color change for the control test tubes 1T and 2T. Test tube 1T contained no BAPNA, and 2T contained the protein but lacked the digestion enzyme; therefore the contents remained clear. Additionally, test tube 3T containing boiled, and therefore denatured, trypsin also showed no reaction and remained clear. Test tube 4T showed a reaction due to the presence of the protein and enzyme together at 37°C. However, when the same contents were incubated at 0°C, the enzyme was deactivated and a color change was not observed.

The data from Table 3 show the expected results for the control test tubes 1L and 2L. Test tube 1A contained pancreatin and water, but there was no litmus cream and the acidic contents did not show a color change, while test tube 2L contained litmus but there was no lipase enzyme and the contents remained blue. When the pancreatin was boiled before adding the litmus cream in tube 3L these contents also remained blue because there was fat but the enzyme had been rendered ineffective due to the higher heat. Test tube 4L turned pink from the fat being broken down into fatty acids, but when it was incubated at 0°C there was no color change because of the colder temperature. Test tube 4B turned a reddish color because the addition of bile salts emulsified the fat, but when test tube 5B was incubated at 0°C the contents remained blue.

References

Fundamentals of Anatomy & Physiology, 11th ed., 2018, by F. Martini; Pearson Education, Inc.

Human Anatomy & Physiology Laboratory Manual (Fetal Pig), 13th ed., 2019, by E. Marieb, Pearson Education, Inc.