Laboratory 3: Biological Molecules

Today we will be testing a meal to determine which biological components (sugar, starch, or protein) they contain.

A. Carbohydrates

**Carbohydrates** contain mostly carbon, hydrogen and oxygen and serve as a source of quick energy for life. The word saccharide comes from the Greek word meaning sugar. **Monosaccharides** are the simplest carbohydrates consisting of a single sugar molecule. Monosaccharides are also referred to as simple sugars. Two sugar molecules connected together are called disaccharides. Large chains of sugars are known as **polysaccharides**, these are also known as complex carbohydrates.

1. Simple Sugars

Benedict’s solution is used to test for simple sugars. Benedict’s solution contains cupric ions (Cu$^{2+}$). Benedict’s solution changes color from blue to brick red when the cupric ion is reduced to Cu$^{+}$. Only sugars that are able to reduce the cupric ion will produce the color change. Reducing sugars contain a free aldehyde (CHO). Glucose is a reducing sugar (see figure below), the free aldehyde is carbon #1 in this figure. In solution the ring configuration is favored but the chain configuration is the structure that is the reducing sugar. There is enough of the chain configuration in the solution to make glucose a strong reducing agent. The Benedict’s reagent will produce a positive response for glucose but not for fructose (see figure). This is because fructose does not have a free aldehyde. This means that Benedict’s test for sugars will only be positive for some of the sugars.

**Procedure 1:** Using Benedict’s solution to test for simple sugars

**Step 1:** Add about 5 mL of glucose solution in one tube, this will be your positive control.
**Step 2:** Add about 5 mL of water to one tube, this will be your negative control.
**Step 3:** Add about 5 mL of each blended item to separate test tubes. For example the blended chicken will be added to one tube and the blended bun will be added to another tube.
**Step 4:** Place 1 ml of Benedict's solution into six test tubes.
**Step 5:** Mix the contents in the tubes. (I will be able to tell if you don’t mix them)
**Step 6:** Place each tube in a boiling water bath for about five minutes.
**Step 7:** Using tongs carefully remove the tubes and allow them to cool.
**Step 8:** Record the results and observations in the table. You should record color changes for each food item in the column “Benedict’s” and record if you think there is sugar present in the food under “Conclusions”
Glucose

Fructose
2. Starch

Starch is a polysaccharide; it is a coiled chain of glucose molecules (See figure). We can test for the presence of starch using iodine which only stains coiled polysaccharides.

**Procedure 2**: Testing food items for the presence of starch

**Step 1**: Place 5 mL of each blended food item into separate test tubes.
**Step 2**: Place 5 mL of starch solution into a separate test tube; this is your positive control.
**Step 3**: Place 5 mL of water into another test tube; this is your negative control
**Step 4**: To each test tube, add a few drops of Lugol's iodine solution. You do not need to mix your tube.
**Step 5**: Record your results in the table, see above.

B. Proteins

Proteins are a diverse group of biological molecules. They include enzymes that make reactions proceed faster. There are structural proteins that make spider webs strong and there are proteins that transport things in cells. This laboratory deals with nutritional proteins. All proteins are made up of amino acids that are linked together to form a chain. The structure of an amino acid is shown below; there are 20 amino acids, each with a different substitution for R. For example, when R is CH₃ then the amino acid is alanine.
The chemical ninhydrin can react with the end amino acid in the chain, producing a purple colored product by the following reaction:

\[
\begin{align*}
\text{ninhydrin} & \quad \text{OH} & \quad \text{NH}_3^+ & \quad \text{CO}_2^2 \quad - \quad 2 \text{H}_2\text{O} \\
& \quad \text{OH} & \quad \text{NH}_3^+ & \quad \text{CO}_2^2 \\
\end{align*}
\]

Procedure 3: Testing for the presence of amino acids and proteins.

Step 1: Place 5 mL of each blended food item in separate test tubes.
Step 2: Place 5 mL of albumin (egg white protein) in a separate test tube (positive control).
Step 3: Place 5 mL of water in another test tube (negative control).
Step 4: Add a few boiling chips to each tube.
Step 5: Add 10 drops of 0.3% Ninhydrin to each test tube.
Step 6: Mix the contents of each tube.
Step 7: Heat the test tubes to boiling, remove tubes using tongs and then allow them to cool.
Step 8: Record the results in the table.

<table>
<thead>
<tr>
<th>Food Item</th>
<th>Benedict’s</th>
<th>Iodine</th>
<th>Ninhydrin</th>
<th>Conclusion</th>
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</thead>
<tbody>
<tr>
<td>Water (- control)</td>
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<tr>
<td>Positive control</td>
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<td>Chicken</td>
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<td>Bun</td>
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<td>French Fries</td>
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<td>Soda</td>
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