Determination of Specific Nutrients in Various Foods

Abstract

Humans need to consume food compounds such as carbohydrates, proteins, fats, and vitamins to meet their energy requirements. In this lab, reagents were used as indicators to test common food substances for the presence of specific nutrients. Meat and eggs tested positively for protein, while fruit, cereal, bread and potatoes tested positively for starch and glucose. Meats and oils had a high fat content, and potato chips and frozen pizza had a high sodium content. None of the foods tested in this lab would individually be able to meet all of our body's requirements for essential food compounds. Therefore, it is important to eat a variety of foods that provide just the right balance between carbohydrates, proteins, and fat.

Introduction

This lab focuses on the body's need for carbohydrates, proteins, and fats to obtain energy. The first law of thermodynamics states that energy cannot be created nor destroyed, but can change form. Humans must harvest a lot of the energy required for life from the chemical energy stored in food. Humans digest the food into simple compounds such as glucose, amino acids (protein), and fatty acids. Our cells break the compounds down further, releasing free energy which can be used for cellular work such as growth, muscle contraction, and tissue repair (*Biological Science An Ecological Approach*, 1992 & *BSCS Biology A Molecular Approach*, 2001). Carbon is the central element for all living things. Carbon atoms can combine with hydrogen, nitrogen, oxygen, sulfur, and phosphorus to form organic compounds. Three basic types of organic compounds are found in all organisms: carbohydrates, lipids, and protein. Carbohydrates and lipids are important energy-storing compounds that contain carbon, hydrogen and oxygen. Simple sugar molecules, such as glucose, are broken down by chemical reactions in the cells during cellular respiration to release energy. Starch, a complex carbohydrate that is used for energy-storage in plants, is a good source of food for humans.

Oils and fats are lipids, and gram per gram contain more than twice the amount of energy found in carbohydrates (*Biological Science An Ecological Approach*, 1992). This makes fat an excellent source of energy. Fat, however, contributes more than energy to the body. It is composed of fatty acids that can be saturated, monounsaturated, or polyunsaturated. Both saturated and monounsaturated fatty acids can be synthesized by the human body and so are not necessary in the diet. In contrast, polyunsaturated fatty acids (PUFA's), referred to as essential fatty acids, are essential for life but cannot be synthesized by the human body. These PUFA's must be consumed in food. They are involved in many important processes such as regulating blood clotting, maintaining the membranes of cells, maintaining healthy cholesterol levels, and facilitating the absorption of fat-soluble vitamins (A, E, K, and D) from food. (*The Vegan Society: Essential Fatty Acids*, 2003).

While carbohydrates and fats are important sources of energy, proteins play a very important role in the body as a basic building block for many physiological processes. The subunit of a protein molecule is an amino acid, which is the basic unit of the genetic code. Composed of carbon, hydrogen, oxygen and nitrogen, amino acids combine to form simple or complex proteins that play important roles in building cellular structures and catalyzing reactions. Since animals cannot synthesize all of the amino acids, they must obtain some of them—the essential amino acids—from food (*Biological Science An Ecological Approach*, 1992).

The main objective of this lab is to determine the chemical composition of various food items. Adding specific reagents to small amounts of common foods and observing their reactions allows us to determine the presence of key nutrients in the sample food: sugar, starch, protein, Vitamin C, chloride, and fat. The purpose of this lab is to learn about the nutritional composition of various foods taken from the average American diet. Some of the questions that this lab will help answer include: (1) Does food coloring interfere with the nutritional analyses of select foods through reagent testing? (2) Which food item has a proportional nutritional composition for all six food compounds? (3) Are foods that show a proportional nutritional composition for all six food compounds the best sources of energy for the body?

Methods

Part A: Using Indicators to Determine Compounds Present in Foods

In order to establish a baseline, five reagents were used to test for known nutrient compounds found in certain foods. First, five test tubes were labeled (test tubes #1-5) with the first five food substances listed in Table 1. Five mL of 10 % gelatin suspension followed by 10 drops of Biuret solution were added to test tube #1. Five mL of 10% glucose solution followed by 3 mL of Benedict's solution were added to test tube #2. Test tube #2 was then placed in a beaker of boiling water for five minutes and then allowed it to cool. It was necessary to heat the solution to boiling for the Benedict's solution to react by changing color. Five mL of 10 % starch solution and 5 drops of Lugol's iodine solution were added to test tube #3. Five mL of 1% ascorbic acid followed by 8 drops of indophenol were added to test tube #4. Five mL of NaCl solution followed by five drops of silver nitrate solution were added to test tube #5 to determine how many drops would be necessary to form a white precipitate. The five reagents added to test tubes #1-5 were used to test for protein, simple sugars, starch, Vitamin C, and chloride (salt). Observations for test tubes were recorded based on a color index for a reagent or by the number of drops required to form precipitate (see Table 1).

To test for fat, 1 mL of vegetable oil and ¼ teaspoon of butter were each rubbed on a piece of brown wrapping paper. The paper was held up to the light and rated according to its level of "greasiness."

Part B: Discovering Compounds in Common Foods

The same reagents used in part A were used to test selected food items for the presence of protein, simple sugars, starch, fat, Vitamin C, and chloride. All foods were chopped into small pieces and blended with water in a food processor until they were of paste consistency. Ten test tubes were labeled with the name of each food item, and 5 mL of each food was placed in the corresponding test tubes. Reagents were added to each test tube as follows: 10 drops of Biuret solution, 3 mL of Benedict's solution (the test tube was heated and then cooled as described above), 5 drops of Lugol's iodine solution, 8 drops of indophenol, and 5 drops of silver nitrate solution. Observations were recorded for each test tube.

Finally, each food paste was rubbed on a brown wrapping paper in a test for fat. The paper was held up to the light to determine if the food left a grease smudge as described above. If no fat was detected the food was dissolved in a 99% isopropyl alcohol solution for five minutes. The solution was then poured on the brown paper and allowed to dry for ten minutes before observation.

Table 1. *Reagent tests of known nutrients for specific food substances*

Food substance	**Reagent**	**Nutrient**	**Indicator Response**
Gelatin suspension	Biuret solution	Protein	Light lavender (4)
Glucose solution	Benedict's solution	Sugar	Bright yellow (3)
Starch solution	Lugol's iodine solution	Starch	Dark blue (4)
Ascorbic acid solution	Indophenol solution	Vitamin C	Colorless (5)
NaCl solution	Silver nitrate solution	Chloride	3 drops*
Butter	None	Fat	Level 5 greasy spot**
Vegetable oil	None	Fat	Level 5 greasy spot**

Note: Numbers in parentheses indicate the range of response for each reagent:
Biuret solution: 1 = pink, 5 = purple; Benedict's solution: 1 = green, 3 = yellow, 5 = orange; Lugol's iodine solution: 1 = light blue, 5 = black; Indophenol solution: 1 = blue, 5 = colorless
*Silver Nitrate solution: Number indicates the number of drops necessary to form a white precipitate in solution.
**No greasy spot left on brown paper = 1; Greasy spot seen on brown paper only after food solution is dissolved in isopropyl alcohol = 3; Greasy spot clearly seen when rubbed on brown paper = 5

Results

Reagent tests of the foods selected for this lab show that each food tests positive for at least three of the nutrients described above (see Table 2). Potato chips were the only food tested that contained all six compounds. Both pepperoni pizza and donuts contained all the food compounds except Vitamin C. Sugar was found in all substances except the eggs, hamburger, and hot dot. All food substances except the hamburger and hot dog contained starch. All of the food substances tested positively for protein except cheerios, the orange, and the carrot. Vitamin C was found in the eggs, orange, carrot, and potato chips only. All food substances contained chloride except the eggs, milk, orange and carrot. Lipids were found in hamburger, hot dogs, potato chips, pepperoni pizza, and the donut with trace amounts in the cheerios (Table 2).

Table 2. *Analysis of Compounds in Common Foods Using Known Reagents**

		Compound				
Food Substance	Protein	Sugar	Starch	Vitamin C	Chloride	Lipid
Eggs	5	0	4	3	0	0
Milk	1	2	3	0	0	0
Cheerios	0	5	4	0	5	2
Orange	0	3	3	5	0	0
Hamburger	5	0	0	0	2	5
Hot Dog	5	0	0	0	4	4
Carrot	0	4	3	3	0	0
Potato Chips	1	5	5	3	4	4
Pepperoni Pizza	5	3	3	0	4	5
Donut	1	4	3	0	2	5

Notes: 0 indicates no change in indicator and negative result for compound.
-Biuret solution test for protein: 1 = pink, 5 = purple;
-Benedict's solution test for glucose: 1 = green, 3 = yellow, 5 = orange;
-Lugol's iodine solution test for starch: 1 = light blue, 5 = black;
-Indophenol solution test for Vitamin C: 1 = blue, 5 = colorless;
-Silver Nitrate solution test for Chloride: Number indicates the number of drops necessary to form a white precipitate in solution.
-Fat test: no greasy spot left on brown paper = 1; Greasy spot seen on brown paper only after food solution is dissolved in isopropyl alcohol = 3; Greasy spot clearly seen when rubbed on brown paper = 5

Discussion

Results indicate that eggs, milk, hamburger, hot dogs, and pepperoni pizza are good sources of protein necessary for cell replication and the structure and growth of the cell. Starch and glucose are indicators of foods high in carbohydrate, a good energy source. As seen in table 2, all foods, except the hamburger and hotdog, tested positively for these carbohydrates, indicating they are good sources of energy for the body. Foods without both carbohydrates and protein will not provide the necessary nutrients humans need.

Potato chips were the only food tested that contained all six compounds, but the high fat and chloride concentration are detrimental to good health. This means that a food item, which contains a balanced proportion of nutrients, is not necessarily the healthiest option. Both pepperoni pizza and donuts contained all the food compounds except Vitamin C. Pepperoni pizza would seem to be the most optimal choice of the two given its higher concentration of protein and lower concentration of glucose. However, its high concentration of chloride, indicating high sodium concentration, is connected with hypertension.

Further, Vitamin C was found only in the eggs, orange and carrot. Vitamins are necessary for metabolism, so foods such as these that are rich in vitamins must also be consumed. Sodium chloride is needed only in small amounts in the body and all food substances contained chloride except the eggs, milk, orange and carrot. High concentrations of lipids were found in hamburger, hot dogs, potato chips, pepperoni pizza, and the donut with trace amounts in the cheerios. Although a small amount of lipid is necessary for energy, high concentrations will lead to obesity, a major health problem in the USA, so foods like these should be avoided.

Based on this analysis no one food tested in this lab meets our body's need for essential food compounds, although pepperoni pizza came the closest. Therefore, it is important to eat a mixture of foods high in carbohydrates like sugar and starch as well as those high in protein and vitamins, while eating small proportions of foods low in salt.

The original colors of the foods tested might have affected the results. Cheerios were found to contain no chloride, but this may be a bad test result due to the white precipitate and the light color of the cheerios paste. Similarly, the potato chip may not have as much chloride as a 4 on the indicator scale indicates as noted in Table 2. The hamburger and hot dog mixtures were also problematic in tests for gelatin, glucose and starch due to the dark color of the original food paste so results may be uncertain. The orange and carrot test for glucose may be similarly tainted. Results here are consistent with results for other students in the lab. It would be interesting to conduct similar tests with other common foods in order to determine a list of high protein, high carbohydrate and low fat foods. A test for calories, or the energy content of foods, could be used to compare the food compounds with energy contained in the food. Further investigation could be done in modifying the diet of individuals eating the foods tested for weight gain and vitamins present in the body.

Conclusion

In this lab I learned that by adding specific reagents to given food items, you can test for the presence of a particular nutrient. From my observations, I learned that the concentration of nutrients varies from food to food. Foods high in glucose and starch such as fruit, vegetables, breads, and cereals seem to be a good source of energy. Also, foods high in protein, such as meats and eggs, seem to be a good source of energy and a requirement for efficient metabolism and building of cells. Foods that have all the major nutrients are not necessarily the most optimal choice for an energy source. Finally, I learned that certain aspects of a food item, such as color, could interfere or hinder reagent activity when testing for specific nutrients.

Note:

This lab is based on Investigation 4.2, "Compounds in Living Organisms," p. 87, from *Biological Science An Ecological Approach, 7th edition* © Copyright 1992 BSCS.

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