Fat chemistry

Subject Area(s) Chemistry, measurement

Associated Unit None

Associated Lesson None

Lesson Title All fat is *not* created equal!

Header Insert Figure 1 here, right justified

Figure 1

ADA Description: Picture of french fries, which are commonly fried in trans fats, beside a flask containing an oil sample

Caption: The properties of oils used in common foods can be examined through science!

Image file: frenchfries_transfat.jpg

Source/Rights: Copyright © 123rf.com

Grade Level 7 (5-7)

Lesson Dependency None

Time Required Two one hour sessions

Group size 4

Expendable cost/group US$10

Summary

In this exercise students will learn that the fats found in the foods we eat are not all the same. Students will be provided with several samples of commonly used fats with differing chemical properties, such as olive oil or vegetable oil, shortening, animal fat, and butter as well as 4 samples containing varying amounts of trans fat. Due to their different chemical structures, these fats exhibit different physical properties, such as melting point and color. This exercise uses the fact that fats are opaque when solid and translucent when liquid to determine the melting point of each sample upon being heated using light and temperature sensors on a Lego NXT robot. Each group builds a simple Lego robot that uses temperature and/or light sensors to determine the melting point of each fat sample. Students heat the samples, and use the robot to determine when the sample is melted. Students record the melting points of the various samples, and can also plot melting point versus fat sample composition. The melting point of these oils is measured and compared, and discrepancies are ultimately correlated to differences in chemical structure and composition of the fats.

Engineering Connection

Students will learn to design a setup for engineering experimentation. This experiment teaches students that physical properties of materials are related to their chemical

structure. Students are required to build a robot that will be able to take reflected light and temperature readings from the sample as it is heated. The students will have to plot the data they collect to correlate the melting point to the sample composition. Finally, the students will analyze the data to determine the trend.

Engineering Category #1, relates science concept to engineering

Keywords chemistry, melting point, phase change, robot, temperature, fat

Educational Standards

- New York State standards:
  - Standard 1, mathematical analysis, key idea 2, M2.1a
  - Standard 1, scientific inquiry, key idea 2 (S2.1) and key idea 3
  - Standard 2, information systems, key idea 1, 1.4
  - Standard 6, interconnectedness: common themes, key idea 2
  - Standard 4, key idea 5

Pre-Requisite Knowledge

data collection, data plotting, proper and safe usage of Bunsen burners

Learning Objectives

After this lesson, students should be able to:

- construct a Lego robot to perform a specific type of measurement
- understand the basics of Lego MindStorms programming software and be able to implement it using their Lego robots
- define what is meant by the term “melting point” and how it is related to chemical composition in fats
- understand how certain properties, such as melting point, can be determined through the measurement of others, such as translucency, of a material

Materials list

Each group will need:

- Lego NXT Kit, including light and temperature sensors
- 4 samples of fats with different chemical structures:
  1. olive oil or vegetable oil
  2. vegetable shortening
  3. animal lard
  4. butter
- 4 samples of fats with different amounts of trans fat:
  1. hydrogenated vegetable oil
  2. partially hydrogenated vegetable oil
  3. vegetable shortening (can use same sample as above)
  4. margarine

- 7 glass test tubes
- Bunsen burner, flame, and gas source
- Small beaker filled with water and a stand to support it over the Bunsen burner
- Container filled with ice to chill the samples

To share with the entire class:

- Computer with NXT MindStorm programming software

Introduction / Motivation

For all materials in our physical world, the physical properties that we can see and touch are defined by the material's chemical properties that are invisible to the human eye. These physical properties affect how we interact with these materials, including how our bodies digest our foods.

In this experiment students will use samples of edible fats to determine what their melting points are, and explore how that information is important for nutrients they put into their bodies. Lipids containing trans fats have recently been shown to be particularly detrimental and dangerous to human health, as their chemical structure leads to melting points above the temperature of the human body. This property makes it difficult for our body to process them, causing trans fats to remain solid in our gastrointestinal tracts and in the bloodstream. Students will learn that fats with higher trans fat content exhibit higher melting points, which makes them all the more dangerous to their health.

Through scientific experimentation and data collection and analysis students will be able to understand the chemical and physical consequences of the food they put into their bodies.

Lesson Background & Concepts for Teachers

Fats are an important class of nutrients found in food. They occur naturally in plants and animals, and are an incredibly efficient way to store energy necessary for biochemical reactions in organisms. The building blocks that make up fat are called fatty acids. One type of fatty acid, called linoleic acid, is actually essential in human nutrition and required in small amounts. Unfortunately, many Americans consume six to eight times the daily requirement of fat necessary, which can lead to health problems.

Students generally understand that food is needed to keep living things alive, and some may understand that certain foods are better for growing bodies than others. Food is commonly broken down into several nutrition groups as a start to a systematic analysis. Fat is one of these groups, but can be further broken down into subgroups, including: saturated fat, monounsaturated fat, polyunsaturated fat, and trans fat. Students need to learn that not all fat that they may ingest is the same, either chemically or physically.

The reason for the discrepancy in melting points exhibited by different types of fat is due to the structure of the fatty acid chains that make up fats and oils. As can be seen in Figure 2, different types of fat have different chemical structures. Note that trans fat and saturated fat are straight, while monounsaturated fat is bent. This leads to

differential packing of the molecules in fats, where straight molecules are able to pack tightly next to one another. Bent molecules have more disorganized packing, making them easier to break apart from one another. This is the reason they have different melting points: less energy is required to break apart bent molecules than closely packed straight molecules. Trans fats have been documented to have melting points in the range of 45 °C, while monounsaturated fats have melting points in the range of 13 °C. With the temperature of the human body being 37 °C, one can see that trans fats will remain solid in the body, leading to an array of complicated health problems is consumed often enough.

Image Insert Figure 2 here, centered

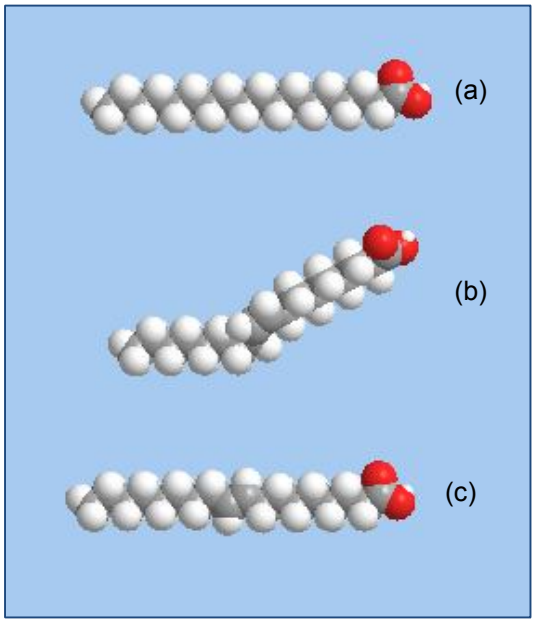


Figure 2

ADA Description: Chemical structures for saturated fat (a), monounsaturated fat (b), and trans fat (c).

Caption: Figure 2. Fat molecules have different chemical structures that can influence their physical properties. Molecule (a) is saturated fat, (b) is monounsaturated fat, and (c) is trans fat.

Image file: 3D fatty acids.bmp

Source/Rights: Copyright © 2011 Jasmin Hume, created with ChemBio3D Ultra software

One goal of this exercise is to help students become aware of the different sources of fats in their diets, and understand that these fats can be beneficial or detrimental to their health based on their chemical and physical properties. Taking measurements of the melting temperature of these samples will help them realize that fats that remain solid at higher temperatures are more difficult for our bodies to process.

Vocabulary / Definitions

Word	Definition
Temperature	Degree of hotness of coldness measured on a definite scale
Melting point	The temperature at which a solid melts
Phase change	Change of physical phase of a material: from solid to liquid, liquid to gas, or the reverse of either of those processes
Opaque	Blocking the passage of light
Translucent	Transmitting light through an object
Fatty acid	any of the saturated or unsaturated monocarboxylic acids that occur naturally in the form of glycerides in fats and fatty oils
Lipid	A class of molecules that is insoluble in water, including fats, grease, and oils. They are the principal structural component of living cells.
Saturated fat	Fats in which all carbon atoms are bonded to hydrogen atoms and contain no double bonds between the carbons.
Monounsaturated	Fatty acid molecule that contains one double bond, and has 2 fewer hydrogen atoms than a saturated fat.
Polyunsaturated fat	Fatty acid molecule that contains more than one double bond, and has a reduced number of hydrogen atoms.
Trans fat	A commercially produced (ie. not naturally occurring) form of monounsaturated fats, where the carbon chains on either side of the double bond are arranged opposite to one another (ie. trans).

Procedure

Before the activity:

1. Prepare samples of oil and fat to be used. Seven samples (*per group*) should be prepared in total: olive/vegetable oil, vegetable shortening, animal lard, butter, hydrogenated vegetable oil, partially hydrogenated vegetable oil, and margarine.
2. Store the samples in a refrigerator or on ice until used.
3. Create the Lego MindStorms program that is to be used by the robots designed by the students. Follow the program schematic in Figure 3 as a guide. Be sure to explain the function of the program to the students.
4. Have the students design their own robot that will be used to measure the melting point of a fat sample, utilizing both the temperature and light sensors.

Image Insert Figure 3 here, centered

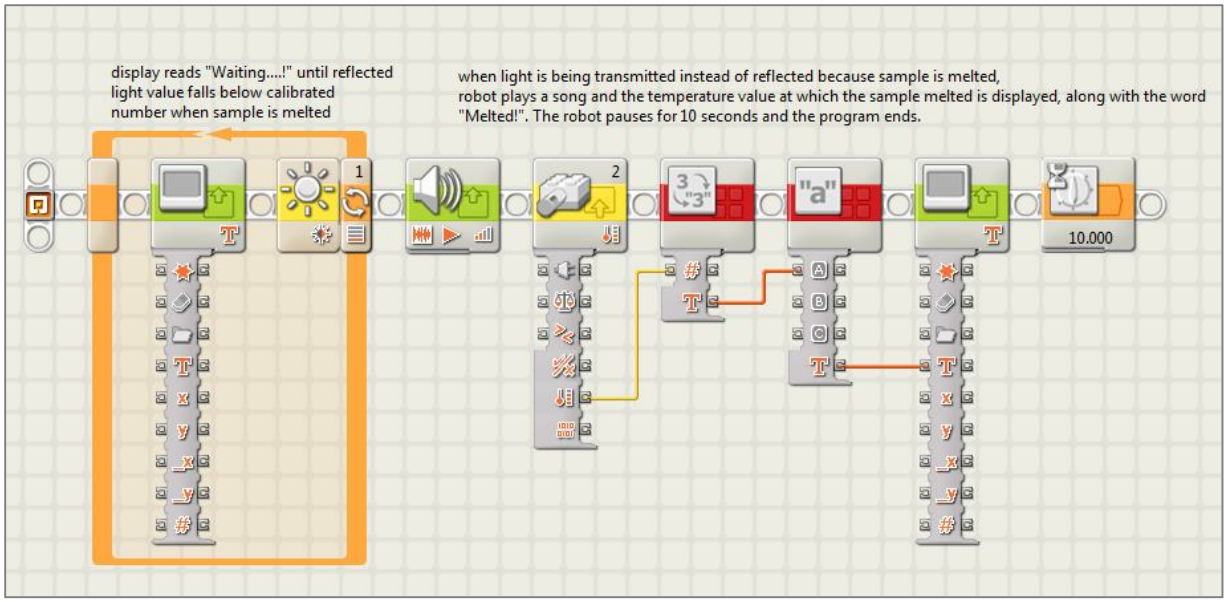


Figure 3

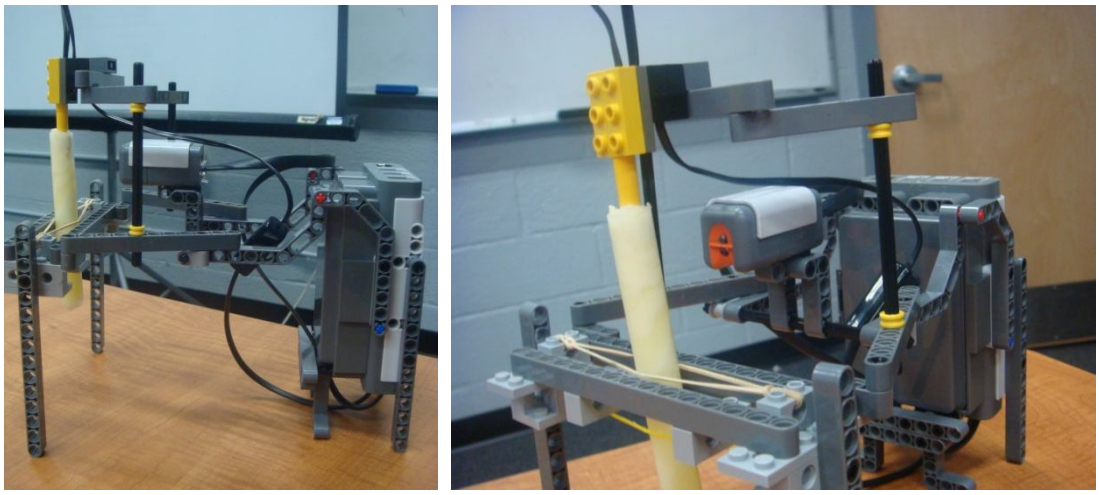
ADA Description: Schematic of program created with Lego MindStorms to perform reflected light and temperature readings of a fat sample.

Caption: Figure 3. Robot program created with Lego MindStorms that enables the robot to detect when a sample of fat has been melted. Upon melting, the melting temperature is displayed on the NXT screen.

Image file: screenshot2.png

5. Give a brief lecture on how chemistry of fats is related to its physical properties. Explain that when a fat is solid it is opaque, while when it melts it becomes translucent. This fact can be used to determine when the sample has melted based on its translucency.
6. Demonstrate the measurement using the robot for the class. Use the setup shown in the image below.

Image Insert Figure 4 here, centered



(a) (b)

Figure 4

ADA Description: Setup example of Lego robot created to measure reflected light and temperature of a fat sample, shown by side view (a) and front view (b). Fat sample is contained in a test tube and heated over a Bunsen burner.

Caption: Figure 4. Setup of Lego robot created to measure reflected light and temperature of a fat sample, shown by side view (a) and front view (b).

Image file: robot setup.bmp

7. Divide the class into groups of approximately 5 students and supply each group with a Lego kit and the necessary samples.
8. Make sure each student has a handout for the activity.

With the students:

1. Assist the groups in building their robots and the necessary setup for the experiment.
2. Each group should have a Bunsen burner, which is used to heat the water bath containing the sample. While Bunsen burners are in use, groups should be carefully supervised.
3. Groups will test one sample at a time, slowly sample until the robot indicates that the sample has reached its melting point. Each group member documents the melting point on his/her worksheet. This process is repeated for each of the seven samples.
4. For the first group of samples, students should determine which type of fat (saturated, monounsaturated, polyunsaturated, or trans fat) exhibits the highest and lowest melting temperature.

5. For the second group of samples containing varying amounts of trans fats, students should plot the melting point of these samples versus the trans fat content (in weight percent). This is done on the worksheet, provided with pre-labeled axes for the graph.
6. Students should summarize the results of this exercise, as well as what they learned about edible fats, on the worksheet.

Attachments

- Worksheet
- French fry image
- Chemical structure image
- Setup photo
- Screen shot of MindStorms program
- MindStorms program file
- PowerPoint slides

Safety issues

- Girls are required to tie long hair back when working with Bunsen burners
- Students should be informed of the proper use of the Bunsen burner, and be sure to turn off the gas source when it is not in use
- Students must be supervised at all times when using Bunsen burners
- Do not fill test tubes to the top with fat samples, as it can drip out and burn while being heated

Troubleshooting tips

- Ensure that the robots are stable so that the setup does not fall during the experiment
- Instructor must calibrate the light sensor value beforehand to determine when sample is melted

Assessment

Pre-Activity Assessment

Class survey: Survey the students to see if they think all fats they eat are the same. The following preliminary questions can be asked before the lesson:

1. Is fat good for us?
2. Is oil considered a fat?
3. What happens when we heat up fat?
4. What are some examples of fat? Name some physical properties of fats that might differ.

Activity Embedded Assessment

Design a robot: Ask students to design a robot that will be able to sense both reflected light and temperature of a sample. Ask them to demonstrate how their setup will be able to perform the measurements.

Post-Activity Assessment

Data collection: Ask the students to complete the worksheet and collect all necessary data. For the trans fat samples, the students should plot the temperature versus percent fat composition and determine what the trend is.

Activity Scaling

- For lower grades: simply record temperature values, no need to plot
- For upper grades: record temperature values and use composition data found in nutritional information label to calculate the percent composition of trans fat for second sample set. Plot melting temperature versus percent composition trans fat.

Additional Multimedia Support

- PowerPoint slides

References

1. Lodish, Harvey et al. *Molecular Cell Biology*. 4th edition. W. H. Freeman and Company.
2. *Investigation 1: The Fat Test.* Life Science, Food and Nutrition. Full Option Science System. Delta Education.

Redirect URL

http://gk12.poly.edu/amps/

Owners

Jasmin Hume

Contributors

Jasmin Hume

Supporting Program

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