Example Calorimetry Lab Report #2 – Good or In Need of Lots of Work?

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Determination of the Caloric Content of Food Through Calorimetry

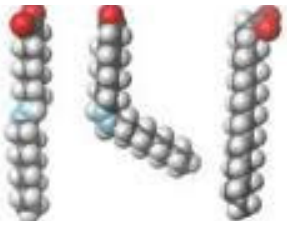
Abstract

In this experiment, the differences in caloric content of foods were investigated through the ignition of food items and the measurement of the thermal energy radiated. Using calorimetry, different types of food were observed to contain varying amounts of potential chemical energy due to the differences in their food molecule composition.

Introduction

The amount of energy contained in food is generally reported as Calories for a given serving size. The overarching question for this investigation is, "Does the number of Calories stored in a food item depend upon its food molecule composition?" More specifically, the question of interest is, "How does the number of total Calories in a food item depend on its various fat molecule content?" It is known that fat or lipid molecules contain long hydrocarbon chains (Figure 1) and that foods contain various types of fat molecules: saturated fats, unsaturated fats, and trans fats. This investigation will address the hypothesis that foods with higher percentages of unsaturated fat molecule content burn longer and have higher Calories. Based on the information gathered in Table 1, it is hypothesized that the peanut will burn the longest and have the most Calories, followed by Cheetos and pretzels.

Figure 1. Structures of three major classes of fat molecules



Trans fat unsaturated fat saturated fat

Table 1. Specific fat molecule content for each food investigated

	Cheetos[1]	**Pretzel**[2]	**Peanut**[1]
% Saturated fat	7.6%	0%	7.1%
% Unsaturated fat	30.4%	3.3%	40.3%
% Trans fat	0.0%	0%	2.5%
Total % fat	38.0%	3.3%	50%

To investigate the amount of energy stored in different types of foods, food items were analyzed using the method of calorimetry. Calorimetry is the measurement of the amount of energy evolved or absorbed in a chemical reaction. Foods containing a larger proportion of calories from fat were compared to foods with a smaller proportion of calories from fat.

The analysis of energy released by the food item utilizes the concept of conservation of energy. The energy emitted by the food item as it reacts is not lost, but transferred to its surroundings via the process commonly known as heat. This is generally observed as a change in temperature. When food is combusted, the reaction that occurs can be represented by the reaction equation:

$$\text{Hydrocarbon (s)} + O_2\ (g) \rightarrow CO_2\ (g) + H_2O\ (g) + \text{heat}$$

The reaction is exothermic and heat is transferred as a result of releasing the chemical potential energy stored in the food item. This process heats the soda can and the water inside it, and a temperature change resulting from the increasing kinetic energy of the water molecules can be observed. By measuring the change in temperature of the water in the calorimeter, it is possible to indirectly determine the amount of energy in food items.

Materials and Methods

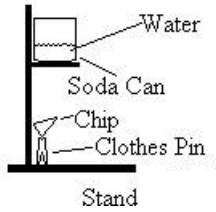
Materials:

aluminum can	ring stand	test tube clamp	clay	clothes pin
cheeto	pretzel	peanut		

Method:

A calorimeter was set up according to the diagram below in Figure 1. The mass of the food item and the temperature were determined before and after the combustion reaction. The teacher was asked to ignite the food item. Fresh water was used for each food item. The height of the can above the food item was controlled and consistent each trial.

Figure 2. Calorimeter apparatus setup



Safety Considerations:

Wear safety goggles when flames are involved.

Results and Analysis

In this experiment, Cheetos were determined to have the greatest amount of Calories per gram. The peanut contained the second most Calories per gram and the pretzel had the least. The length of time each food item burned was recorded and results are displayed in Table 2.

Table 2. Burn times for each food item

Cheetos	Pretzel	Peanut
57.2 seconds	22.1 seconds	93.4 seconds

Table 3 contains the raw data collected and calculated values necessary for determining the number of Calories in one gram of the food item.

Table 3. Raw and calculated data for calorimetric analysis of Cheetos, pretzel and peanut

Food item	**Cheetos**	**Pretzel**	**Peanut**
Initial mass of food + holder (g)	52.1 g	56.3 g	51.1 g
Final mass of food + holder (g)	50.6 g	53.8 g	49.3 g
Mass of water (g)	99.2 g	98.7 g	100.6 g
Initial water temperature (°C)	23.4°C	21.3°C	22.3°C
Final water temperature (°C)	68.4°C	35.5°C	85.4°C
Change in temperature (°C)	45.0°C	14.2°C	63.1°C
Total calories	4464 cal	1402 cal	6348 cal
Total Calories	4.464 Cal	1.402 Cal	6.348 Cal
Calculated energy per gram (Cal/g)	**2.976 Cal/g**	**0.561 Cal/g**	**3.53 Cal/g**
Accepted energy per gram (Cal/g)[1]	5.7 Cal/g	3.82 Cal/g	5.84 Cal/g

Sample calculation for change in temperature: ΔT = (final temperature) – (initial temperature)

ΔT = 68.4°C – 23.4°C = 45.0°C

Sample calculation for total calories in food item: calories = (mass of water)*(ΔT)

99.2 g H_2O (45.0°C) = 4464 cal

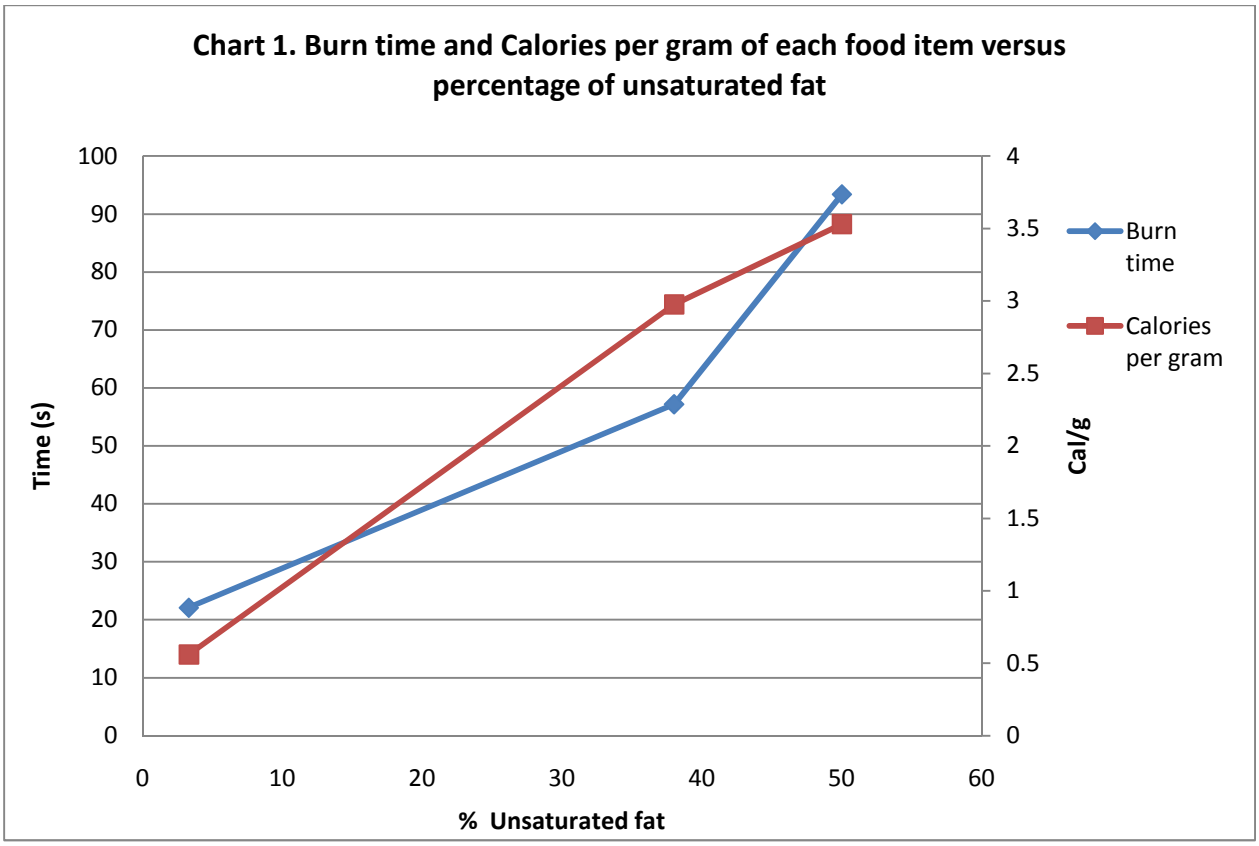
Sample calculation for total Calories in food item: Calories = calories $\times \frac{1\ Cal}{1000\ cal}$

$$2877\ cal \times \frac{1\ Cal}{1000\ cal} = 2.877 Cal$$

Sample calculation for Calories per gram of food: $\frac{Cal}{g} = \frac{Cal}{\Delta\ mass} = \frac{2.877\ Cal}{(initial\ mass) - (final\ mass)}$

$$\frac{2.877\ Cal}{\Delta\ mass} = \frac{2.877\ Cal}{50.6\ g - 52.1\ g} = \frac{2.877\ Cal}{1.5\ g} = 2.976\ Cal/g$$

Chart 1 provides a visual representation of the correlation between both the burn time and Calories per gram and the percentage of unsaturated fat in the food item. Both burn time and the Calories per gram seem to correlate directly with the percentage of unsaturated fat in the food item. As the percent of unsaturated fat increases, so does the burn time and the Calories per gram.



To evaluate the effectiveness of this experiment, percent error was calculated using accepted values determined from nutrition labels.[1,2] The large percent error values indicate that there was a significant discrepancy between the values that were experimentally determined and the accepted values, as shown in Table 4.

Table 4. Summary of results and percent error

Food item	**Cheetos**	**Pretzel**	**Peanut**
Calculated energy per gram (Cal/g)	2.976 Cal/g	0.561 Cal/g	3.53 Cal/g
Accepted energy per gram (Cal/g)	5.7 Cal/g	3.82 Cal/g	5.84 Cal/g
Percent error	66.3%	85.3%	39.6%

Sample calculation for percent error: % error= $\frac{|accepted\ value - experimental\ value|}{accepted\ value} \times 100$

$$\%\ error = \frac{\left|5.7\,\frac{Cal}{g} - 1.92\,\frac{Cal}{g}\right|}{5.7\,\frac{Cal}{g}} \times 100 = 66.3\%$$

Discussion

Calorimetric analysis of Cheetos, pretzels and peanuts showed that Cheetos, and peanuts have the greatest number of Calories per gram. The Cheetos and pretzels results align well with the expectation that foods considered to be "junk food" with high proportions of fat would contain more calories per gram considering that Cheetos are viewed as being more of a "junk food" than pretzels. However, the very high Cal/g value for peanuts shows that the caloric content of food can be high for food that are not considered "junk foods." This is attributed to the types of food molecules that comprise the food item. Analysis of the composition of each food item available at the Self Nutrition Data and Calorie Count sites[1,2] shows that with high total percentages of fat, peanuts (50%) and Cheetos (38%) contain more Calories per gram than pretzels (3.3%). The data also show this same correlation between the unsaturated fat, specifically, and the total Calories per gram.

Although it is possible to compare the results obtained during this experiment with the accepted food nutrition information and see similar trends, these results are still somewhat inconclusive. The 85.3% error obtained for pretzels as seen in Table 2 is significant enough that the resultant trend may not be reproducible should this experiment be repeated. It is likely that error can be attributed to the experimental setup. All of the energy released from the food may not have heated the water. Heat was probably lost to the air and the foil around the food. The Cheetos and pretzels also required reigniting multiple times. Heat was also probably lost to the surroundings during this process. The lighter may also have added heat to the system. Next time, it would be prudent to ignite the food away from the calorimeter and then quickly place the food item under it. With the need to reignite the food items multiple times on occasion, the time measurements were also impacted by variations in reaction times.

Conclusion

Utilizing the concept of conservation of energy to perform a calorimetric analysis on various food items, it was possible to indirectly measure and compare the foods' caloric content and compare this to the molecular composition of the food. This lab helped to improve my understanding of energy conversion and the effect of a food's molecular composition on its caloric content.

As this was the first time I performed error calculations, I have found that it is an excellent way to quantitate the accuracy of my experimental work. This has brought to my attention the importance of considering error sources as I perform lab work. In future experiments, I will work towards reducing the sources of error in my experiment.

References

1. *Calorie Count: There's strength in numbers*. About, Inc., 2011. Web. 24 Oct 2011. <http://caloriecount.about.com/ >
2. *Self Nutrition Data: Know What You Eat.* Condé Nast Digital, 2009. Web. 22 Oct 2010. <http://nutritiondata.self.com/>