Determination of the calorific content of food

Nutrition, Healthy Food

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Aim

In this experiment, foods were burned in order to determine their different caloric content by measuring the radiated thermal energy. Different foods, containing differing amounts of potential chemical energy caused by their different molecular composition, were examined using calorimetry.

Introduction

Being the closest friend of someone who fought for years against obesity is the main reason for me to start thinking deeply in " the fundamental cause of obesity and overweight" which is an energy imbalance between calories consumed and calories expended. As we know, all human activities such as running, talking and thinking need energy which is stored in the food we consume, however not all foods contain the same amount of energy. Thus, this experiment is the key to calculate the amount of energy stored in various foods.

Hypothesis: Energy levels in different foods vary, because of varying components (e. g. carbohydrates, proteins, fats, etc.). The dried fruits will have greater energy content than fresh fruits since dried fruits are packed with fibers, antioxidants and micronutrients.

Background Information

Nowadays, more varied foods are being consumed. An advantage is that this helps in increasing the amount of nutrients that we take in everyday however it has also increased the popularity of less healthy foods (e. g. fried and artificial foods) which raises the number of health diseases, mostly heart attacks, diabetes and obesity.

Thus in order for us to be healthy and limit these diseases, we need to monitor the amount of energy that we consume from our foods. In order to do so, the energy content of food need to be calculated using experimental data. The food is first burned in a calorimeter and then using the mass of the burnt food and the change in temperature, initial and final, that are measured during the experiment, the enthalpy of combustion of foods can be found. This enthalpy can be found using the following equation: $q= m*c*\Delta T$, Where: q= energy content in Joules (J), m= mass in grams (g), c= specific heat capacity of water (J g

-1 °C

-1), T= temperature in degrees Celsius (°C).

Methodology:

1. Secure the coke can in the retort stand. Weigh a 100 grams of water and add it to the can.
2. Place the thermometer in the mouth of the can and close the rest of the can opening with cotton wool to prevent heat loss. Record the initial water temperature.
3. Weigh a sample of food and burn it. Collect all the unburnt food.
4. Record the final temperature of the water, after the food sample completely burns. Weigh the remaining food sample after being burnt and determine the actual mass of the food that has burned.
5. Repeat the procedure for 5 trials for every food sample.

Observations

Fresh Apples: The apples produced some white smoke. The surfaces of the apples began to bubble a short amount of time after introducing it to the heat. It produced black residue on the bottom of the can and few yellow droplets started dripping from the bottom of the can. It took some time to burn the apples to completion.

Dried Apples: Dried apples produced a great deal of white smoke and black residue on the bottom of the can. They burnt to completion easily and shrank to small pieces.

Fresh Mushrooms: Fresh mushrooms bubbled when burned. The size of the mushrooms decreased greatly. They were burned until they were crispy black with a bit of white ash on the surface.

Dried Mushrooms: A bunch of dried mushrooms were collected and burned at the same time in order to achieve a 1-2 grams of this food sample due to their small mass. The remaining of the burnt mushrooms were very small. In the last 2 trials the masses almost reached 1 gram even though they were 3 pieces of dried mushrooms.

Fresh Bananas: Fresh bananas produced a lot of water when burned. All the samples were burned until a very crispy black chunk was remaining with some white ashes forming on the surface. A great deal of white smoke was produced.

Dried Bananas: Dried bananas did not produce flames when burned, unlike all the other food samples. Also, all the samples of this food, dried bananas, were burned until they became almost the shape of charcoal and producing a lot of white and black smoke. It was hard to determine whether the dried bananas were burned to completion or not because there was no change in color and no formation of white ash.

Processed Data

Since the specific heat capacity of water is given, 4. 18 J g

-1 °C

-1, and a 100 grams of water was used, we can calculate the calorific value of food using the equation: q= m*c*ΔT. However, we should also consider the fact that a proportion of the heat released from the food was absorbed by the can as well. If we assume that all the heat was distributed equally throughout the can and that the can underwent the same rise in temperature as the water inside, then we can calculate the amount of heat absorbed. The specific heat capacity of aluminum is 0. 900 J g

-1 °C

-1 and the mass of the can was 13. 10 grams.

To compare these results with the literature value as accurately as possible, we should calculate the average energy per gram of food. This average energy can be calculated using the following formula: Energy per gram= Energy Content/ΔmassTable 9- showing the average change in mass, ΔT, for each type of food.

To determine the accuracy of the results taken from the experiment, the obtained energy content can be compared to the literature values. Table 11- showing the literature value for the energy content of each food type. Food Type Energy Content (J g

-1) Fresh Apples 2260 Dried Apples 11640 Fresh Mushrooms 670 Dried Mushrooms 435 Fresh Bananas 3880 Dried Bananas 12060Table 12- showing the average experimental values of energy content vs literature values. It can be clearly seen from the graph that most of the calculated values from the experiment were much larger than the literature values. The errors will be discussed in the evaluation section. However we can see that almost all the dried foods, apples and bananas, have greater energy content than the fresh foods as expected since they are packed with micronutrients which have the great difference in energy when burnt.

Conclusion

In conclusion, the calorific content of food differs for each type of food due to differences in their constituent molecules. By combusting varying food samples, we can determine their energy content. Although there is difference between the experimental values and the literature values, both of them show similar trends, expect for bananas. In apples, both experimental and literature values showed that dried apples gave more energy when burned than fresh apples. Also both results showed that fresh mushrooms gave off more energy when burned than dried ones. It is only in bananas that the results trend differed where the experimental results showed that fresh bananas gave off more energy than dried bananas whereas the literature values showed the opposite. Even though the trends between the experimental and literature values was similar, except for bananas, the results themselves were inaccurate. However, the data was collected precisely with 5 trials being carried out for each food type in order to reduce the random errors as much as possible. Some literature values were too large to be considered as random errors, this can also be seen from the range of uncertainties calculated. The results were inaccurate to some extent with the literature values. This demonstrates hat the systematic errors were greater than the random errors in this experiment. Graph 1 further demonstrates these discrepancies.

Mushrooms should have the lowest energy, theoretically speaking, yet the experimental results were very large, some of which were larger than the literature values for apples and almost similar to the energy of bananas. However, the experimental and literature values have some shared trends where they both show fresh apples to contain more energy than dried apples and fresh mushrooms also contains more energy than dried mushrooms. The discrepancies might be explained for some of the food samples from the observation section. For example, it was hard to determine whether the dried bananas were completely burnt or not due to their already solid black shape. Furthermore, no white ash formed on the surface of the dried bananas. Since the trends for both literature and experimental values are similar, we can thus conclude that not all of the bananas were burned to completion causing some of the energy contained in them to remain instead of being released during combustion. This can also further be supported by claiming since all the trends are similar in the other food samples, if dried bananas were completely burnt then the trend there should be similar as well, showing dried bananas to have more energy than fresh bananas. This is a systematic error since all the food samples should be burned to completion before stopping the experiment and starting another trial. However this error can only be seen in dried bananas whereas in the other food samples, there is not such an error due to similarities in the trends obtained from this experiment and the literature values.

Nonetheless, the difference in some samples was very large which shows that still there were errors in this experiment. Also some of the heat must have been consumed by air since the food was not combusted in a sealed environment and thus this heat cannot be included in the calculations. This experiment was not able to determine the accurate values of each food type however it successfully demonstrated how foods with differing molecular constitutes differ in their energy content.

Evaluation

Random errors can be reduced by repeating the experiment several times for each food sample. There are few factors that have affected the results of the experiment.

Heat lost: As stated earlier, most of the heat would have been absorbed by air since the food was not combusted in a sealed environment so the temperature change of the water and the can alone do not represent the actual amount of heat released by burning the food. This can be improved however by carrying out the experiment in a bomb calorimeter since it is closed and all the heat will be absorbed allowing all this heat to be included in the calculations.

Incomplete combustion of food: This factor can be clearly seen from the observations of dried bananas and how their incomplete combustion led to a difference in the trend between experimentally determined values and the literature ones since not all of the energy has been released. This can be improved by making sure that all the food samples have burned to completion. Surface area of the base of the can: Some of the heat was absorbed by the base of the can and since this heat cannot be included and calculated this would affect the results. However in the experiment, it was assumed that the heat was distributed evenly throughout the can. This error affects the accuracy of the results. Again using a bomb calorimeter would be the best solution for this case since the heat in such calorimeter will be distributed evenly throughout its surface area.

Black residue forming on the bottom of the can: This black residue formed after combusting foods fro several trials and it might have played a role in the discrepancies caused by absorbing some of the heat and since we cannot add that heat in the calculations, this would affect the results. We can either wash the van after each trial making sure that no more black residue is on the bottom of the can or if we want to use a new can we should first make sure that the weight of the can is the same because it will be later required in calculating the total energy.

Improvements

So in order to improve the experiment and obtain the most accurate data, we can use the bomb calorimeter since it will greatly decrease the amount of heat lost and all of the heat released can be added to the calculations to obtain better data.

Also the next important thing is to make sure that all the food sample has burnt completely otherwise there will be an amount of heat that has not been released but remained in the food sample and thus creating discrepancies in the data. The final important step is to repeat the experiment as many times as possible to decades the chances of random errors occurring. Thus by following all of the above steps, random and systematic errors can be decreased greatly allowing the most accurate data to be collected and then to be compared with literature values.