Quantification of Iron in Whole Grain Cereal

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Abstract

In this experiment, an Atomic Absorption (AA) instrument was used on a cereal sample to find the concentration of iron in the cereal. A calibration curve was made after gathering the absorbance on samples of iron with different concentrations. This calibration curve graphed the concentrations against the absorbance. The calibration curve allowed the use of the Beer-Lambert law, which shows that absorption is directly proportional to concentration, to find the concentration of iron in the original 10g of total cereal. Using this information, the concentration of iron in the original 10g of total cereal was 1.598 ppm.

Introduction

Iron is an important nutrient that helps keep our bodies healthy. It is very important in the making of hemoglobin, the part of our blood that carries throughout the body. Without enough iron, people can feel tired and more lightheaded than normal.[3] Cereals are a great way to get more iron in our diets because they are made to include iron that our bodies can absorb easily. This makes cereals very helpful for people who don't get enough iron from other foods like meat or vegetables.[2] Testing these cereals is important to make sure the iron levels match what the nutrition labels say and to help people meet their necessary iron levels.[1]

In this lab, we will measure how much iron is in a sample of whole-grain cereal using a Atomic Absorption Spectroscopy (AAS). This method measures how much light iron atoms absorb at specific wavelengths, which helps us figure out the amount of iron in the sample.[5] The experiment will use the Beer-Lambert law, which shows how the amount of light absorbed by a solution is connected to the concentration of the substance in it. We will first make a calibration curve using the solutions with known amounts of iron and applying the principles from the Beer-Lambert law. We will then compare our cereal sample to the curve to calculate its iron content.[4] To prepare the cereal for testing, the iron in hydrochloric acid will have to be fully dissolved so it can be properly analyzed by the AAS instrument.[1]

Experimental

Measure approximately 10 g of Total cereal and record the exact mass. Use an electric grinder to grind the cereal into a fine powder. Transfer the powdered cereal into a 250 mL beaker. Add about 150 mL of DI water to the beaker and stir the mixture to create a smooth, runny slurry. Place a magnetic stir bar into the cereal slurry and stir it on a magnetic stir plate for 10 minutes. Carefully pour off most of the cereal mush into a waste container, leaving only the stir bar with the iron particles. Remove the magnetic stir bar from the beaker using tweezers. Use DI water to rinse off any remaining cereal mush from the stir bar. Place the cleaned stir bar, with the iron flakes still attached, into a clean test tube.

Add 6 mL of 6.0 M HCl to the tube containing the iron. Place the test tube in hot water and heat it for about 10 minutes. The iron has dissolved completely when both hydrogen bubbles stop forming and the solution turns light green. Pour the iron solution into a 100 mL volumetric flask. Add DI water to the flask until it reaches the 100 mL mark. Pipette 2 mL of this diluted solution into a separate 10 mL volumetric flask. Add the following to the 10mL volumetric flask: 2 drops of 6.0 M HCl, 0.50 mL of 10% hydroxylamine-HCl, 6 drops of 2.0 M sodium acetate solution, and 1.0 mL of 0.1% 2,2-dipyridyl solution. Fill the remainder to the 10mL mark using DI water. Wait for 15 minutes to let the solution turn red.

Use the Atomic Absorbance (AA) instrument to record the absorbance of the prepared iron at 522 nm. Repeat this process to measure the absorbance of the iron solutions with the concentrations of 0.5, 1, 2, 4, and 5 ppm. Plot the absorbance against their concentrations to create a calibration curve. Use the equation of the line from the calibration curve to calculate the concentration of the iron in the cereal sample.

Results

Table 1. The recordings of different concentrations (ppm) and absorptions of Fe samples

Concentration Sample (ppm) of Fe Samples	Absorbance of Fe Samples
0.5	0.0499
1	0.0869
2	0.1496
4	0.3009
5	0.3531

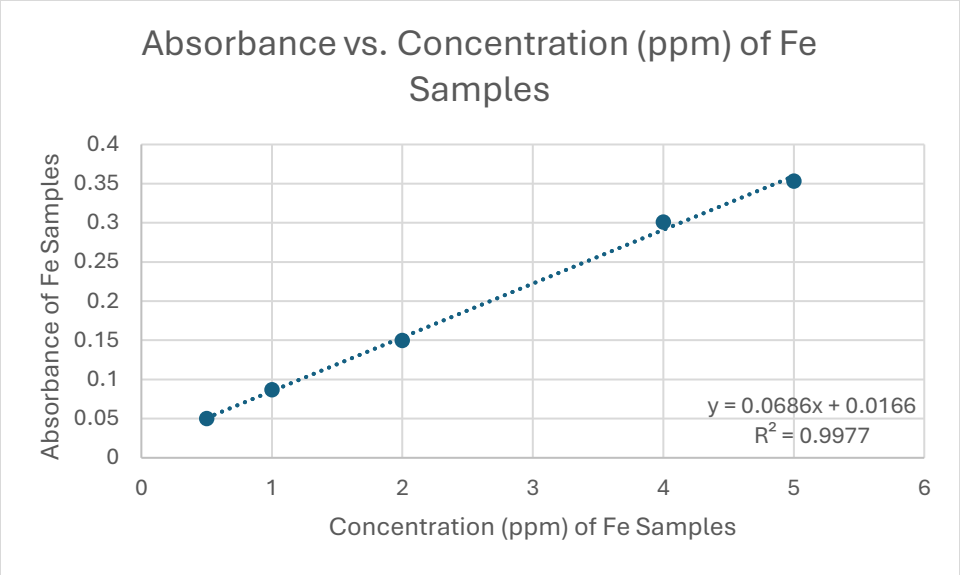

Figure 1. The calibration curve of different concentrations (ppm) and absorptions of Fe samples

$$y = 0.0686x + 0.0166$$

$$0.1262 = 0.0686x + 0.0166$$

$$\frac{0.1262 - 0.0166}{0.0686} = \frac{0.0686x}{0.0686}$$

$$x = 1.598$$

Discussion

Each step in the procedure was important to find out how much iron was in the cereal. Grinding the cereal into a powder helped the iron be easily extracted. Mixing the cereal with water made a slurry, which allowed a magnetic stir bar to pull out black iron flakes. These flakes were rinsed to remove leftover cereal and then dissolved in hydrochloric acid. The solution turned pale green, and bubbles of hydrogen gas were released, showing that the iron had fully dissolved into $FeCl_2$. After diluting the solution, 2,2-dipyridyl was added, which caused the solution to turn red. This color change allowed us to measure the absorbance of the solution at 522 nm. The dilutions made sure that the iron concentration stayed within the range of the spectrophotometer for an accurate result.

The calibration curve made it possible to find the iron concentration in the cereal. Using the Beer-Lamber law and its relationships, five different iron samples were plotted to create the curve. The equation of the line was used to calculate the concentration of the cereal solution from its absorbance value using the relationships from the Beer-Lambert law. The R^2 value of 0.9977 showed a strong linear relationship between absorbance and concentration, meaning the data was most likely reliable. Because the original cereal solution was diluted, the calculated

concentration was adjusted using the dilution factor to determine the actual iron content in the cereal. Without these dilutions, the iron concentration might have been too high to get an accurate measurement.

Volumetric glassware, like flasks and pipettes, was important for accurate measurements throughout the experiment. These supplies are designed to measure exact volumes, which is important when preparing dilutions and standard solutions. Precise measurements ensured that the right amount of solution were added for every step, keeping the results consistent and reliable. If glassware with inaccurate measurements were used, small errors in volume could have caused the calculated concentrations to be wrong, leading to unreliable results from the collected data.

The iron content measured in the lab might not perfectly match the value listed on the cereal's label. Some iron might have been lost during and moving it into the tub, or the cereal flakes may not have dissolved completely. The label also provides an average value that can vary between batches of cereal. These factors explain why the lab results may differ from the label, but the experiment still provides a reliable method for analyzing the iron content in food.

Conclusion

The main goal of this experiment was to determine the amount of iron present in whole-grain cereal. Using spectrophotometric analysis and creating a calibration curve with absorbance values from known iron standards, we calculated the concentration of iron in the cereal. There may have been small errors during the experiment, such as loss of iron during extraction or slight inaccuracies in the dilution steps. Although we used precise volumetric glassware to minimize these errors, some uncertainty is still possible. By performing this experiment, we learned how light absorbance can be used to calculate the concentration of a substance and how calibration curves provide a reliable method for analyzing unknown samples.

References

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