Potassium Determination in Bananas by Atomic Absorption

Abstract: The theme and objective of this experiment was to determine the amount of potassium in a Chiquita™ banana using Atomic Absorption (AAS). To accomplish this, potassium was extracted from a banana using a 120mL mortar and pestle. Potassium exists in ionic form in bananas initially therefore the simple addition of water will aid in extracting the ion. Hydrochloric acid was added as well to attract the potassium ions (the potassium is attracted to the negative chloride ions). By adding these two things in conjunction with rigorous shaking, the potassium containing supernatant was filtered out, obtained, and diluted for measurement. A series of potassium standards were prepared as well. Simple dilution factors were calculated to create seven standards (1ppm-7ppm) from a 100ppm K⁺ Stock solution. These standards were measured in the AAS machine to create a calibration curve that was utilized in quantitatively determining the amount of potassium in bananas. The unknown banana solution was then measured in the AAS, and from the absorbance of the measurement the concentration was obtained using the calibration curve. In-order to eliminate any chemical interference, standard addition was performed. This was done by adding a known amount of standard to unknown potassium solutions to account for the interference, and then running them through the AAS machine. The results were then compared to the calibration curve previously made in order to calculate the amount of potassium that exists without interference. This step was necessary to obtain accurate potassium amounts. The motive behind this experiment was to quantitatively determine the amount of potassium in order to compare it to the amount humans need to survive. Potassium uptake is crucial in many biological processes; therefore it is imperative that humans obtain the rights amounts. Can a substantial amount of potassium be obtained from eating bananas? In this experiment, 174.5218 ± 0.04598mg K⁺ was determined to be present in the banana. Humans require 4700mg of potassium per day (Jones). One would have to eat approximately 27 bananas to obtain the daily amount of potassium needed for survival. Therefore the results show that bananas are not a significant source of potassium.
**Introduction:** Potassium is crucial for many biological processes that occur in humans. It is essential for survival and deficiency can cause serious risks. “Potassium is fundamentally involved in a massive amount of body processes, such as fluid balance, protein synthesis, nerve conduction, energy production, muscle contraction, synthesis of nucleic acids, and control of heartbeat. In many of its roles, potassium is opposed by sodium and the two positive ions are jointly balanced by the negative ion, chloride” (natural-health-information-centre.com). Because potassium is so crucial to human life, it is essential to make sure one’s intake of potassium is sufficient for human survival. Due to this concept, the amount of potassium in bananas was determined to calculate if a banana is an adequate amount of potassium for human survival. Humans require 4700mg of potassium per day (Jones). In order to determine the amount of potassium in bananas Flame Atomic Absorption was used. The first step was to extract the potassium from the banana. This was done by crushing it with a mortar and pestle, the addition of water, and the addition of .1M hydrochloric acid. Potassium exists in ionic form in bananas, therefore the addition of water and hydrochloric acid caused an attraction between the negative ions and the positive potassium ions, allowing it to be separated from the banana in the supernatant. Vigorous shaking was applied as well to ensure complete extraction. After extraction, the supernatant was diluted. After making the unknown potassium/banana solution, a series of standard potassium solutions were synthesized in order to construct a calibration curve necessary for concentration determination. These standard solutions and the unknown potassium/banana solution were then measured in the AAS machine. “In flame atomic absorption spectroscopy a liquid sample is aspirated and mixed as an aerosol with combustible gasses (acetylene and air or acetylene and nitrous oxide.) The mixture is ignited in a flame of temperature ranging from 2100 to 2800 degrees C (depending on the fuel gas used.) During combustion, atoms of the element of interest in the sample are reduced to the atomic state. A light beam from a lamp whose cathode is made of the element being determined is passed through the flame into a monochronometer and detector. Free, unexcited ground state atoms of the element absorb light at characteristic wavelengths; this reduction of the light energy at the analytical wavelength is a measure of the amount of the element in the sample” (Ecology). Because the potassium is aspirated, it is in its purest form, therefore producing a precisely accurate measurement of absorbance. Due to the many components of bananas, matrix effects were anticipated in this measurement. Therefore, standard addition was performed to work with interferences without the scope of removing the interfering species. Standard addition is as test technique for investigating suspicious test results. To accomplish this, the potassium standard solutions were added to the unknown potassium/banana solution in varying amounts (spiking). Then, from the increase in signal the amount of analyte originally present in the sample was deduced. This amount was calculated to be 174.5218 ± 0.04598mg K⁺. As previously stated, humans need 4700mg of potassium per day in order to survive with good health. This experiment has proven that even thought bananas contain potassium; they do not suffice for the potassium intake that is necessary for humans (unless one was to eat 27 bananas per day). Therefore potassium is obtained also through many other foods.
Experiment: The apparatus for the experiment includes the Perkin-Elmer 2100 Atomic Absorption Spectrometer, and a Hollow Cathode Lamp for the element to be analyzed.

A Mettler AE260 DeltaRange balance was also used to take measurements of the potassium chloride, and the sample of banana. The potassium chloride was used to make the standard solutions in order to construct the calibration curve. The potassium chloride used was Fisher Scientifics’ S272-500. Hydrochloric acid was also used in conjunction with water to aide in extraction of the potassium from the banana. The Hydrochloric acid that was used was BDH ARISTAR CAS # 7647-01-0. A 120mL mortar and pestle was used to aid in extraction as well. The banana used in this experiment was a Chiquita™ banana that weighed 132.382g.

Procedure: The first step in this experiment includes the synthesis of the potassium standard solution. This was accomplished first by dissolving .1151g of KCl in 1L of water to produce a 100ppm solution. From this solution seven standard solutions were prepared using dilution factors. The solution concentrations consisted of 1ppm, 2ppm, 3ppm, 4ppm, 5ppm, 6ppm, and 7ppm. To make each standard solution, for example the 1ppm solution, one milliliter of the 100ppm standard solution was transferred to a 100mL flask, using a 1mL pipette, and then diluted to the 100mL mark. The same process was used for the rest of the standards, except 2mL of potassium standard was used in the 2ppm, 3mL in the 3ppm, and so on. After the construction of the seven standards, the unknown solution was made. The entire banana was weighed (minus the peel), and then four grams of it was measured out for analysis. This was then crushed using a mortar and pestle with 32mL of water (1:8 dilution) for extraction. 25mL of HCl was then added to a 25mL aliquot of the diluted banana solution for extraction as well (1:16 dilution). The solution was shaken vigorously for ten minutes. The solution was then filtered and diluted 1:62.5. The unknown solutions were then measured along with the standards to create a calibration curve for determination of potassium content in the unknown solutions. After these measurements were taken standard addition was then done to account for any unknown matrix effects. This was done
by varying the amounts of 100ppm potassium standard solution in 100mL volumetric flasks. There were seven flasks, and the first one had 1mL of 100ppm potassium solution, the second had 2mL, the third had 3mL...etc. Each solution had a constant amount of unknown banana solution added (2mL) and then they were diluted to the 100 mark. These solutions are referred to as “spiked.” After making the solutions for standard addition, they were all run through the AAS machine in order to construct a standard addition curve. This curve was used in conjunction with the calibration curve to determine the amount of potassium without interference.

Results and Discussion:

<table>
<thead>
<tr>
<th>Concentration of Standard (ppm)</th>
<th>Absorbance Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.0147</td>
</tr>
<tr>
<td>2</td>
<td>0.0545</td>
</tr>
<tr>
<td>3</td>
<td>0.0977</td>
</tr>
<tr>
<td>4</td>
<td>0.1405</td>
</tr>
<tr>
<td>5</td>
<td>0.1546</td>
</tr>
<tr>
<td>6</td>
<td>0.1994</td>
</tr>
<tr>
<td>7</td>
<td>0.2338</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Unknown Potassium/Banana Solution</th>
<th>Trial 1 (absorbance)</th>
<th>Trial 2 (absorbance)</th>
<th>Trial 3 (absorbance)</th>
<th>Average:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solution 1</td>
<td>0.1417</td>
<td>0.1463</td>
<td>0.1448</td>
<td>0.1443</td>
</tr>
<tr>
<td>Solution 2</td>
<td>0.1481</td>
<td>0.1532</td>
<td>0.1481</td>
<td>0.1498</td>
</tr>
<tr>
<td>Solution 3</td>
<td>0.1440</td>
<td>0.1471</td>
<td>0.1452</td>
<td>0.1454</td>
</tr>
</tbody>
</table>

Mean = .1465  Standard deviation = .003
### Anova Table:

<table>
<thead>
<tr>
<th></th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>t Stat</th>
<th>P-value</th>
<th>Lower 95%</th>
<th>Upper 95%</th>
<th>Lower 95.0%</th>
<th>Upper 95.0%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-0.01554</td>
<td>0.006676</td>
<td>-2.32819</td>
<td>3</td>
<td>-0.0327</td>
<td>0.001618</td>
<td>-0.0327</td>
<td>0.001618</td>
</tr>
<tr>
<td>X Variable</td>
<td>0.035857</td>
<td>0.001493</td>
<td>24.0202</td>
<td>9</td>
<td>2.33E-06</td>
<td>0.039694</td>
<td>0.03202</td>
<td>0.039694</td>
</tr>
</tbody>
</table>

### Concentration Calculation before Standard Addition:

\[ Y = mx + b \]

\[ Y = 0.0359x - 0.0155 \]

\[ X = \text{concentration (ppm)} \]

\[ Y = \text{Absorbance} \]

\[ X = \frac{-0.0155}{0.0359} = 0.43175 \text{ ppm} \]

**Propagation of Error:**

\[ X \pm e_X = \frac{0.0155 \pm 0.006676}{0.0359 \pm 0.001493} \]

\[ X = 0.43175 \pm \sqrt{\%e_{x1}^2 + \%e_{x2}^2} \]

\[ X = 0.43175 \pm \sqrt{43.071^2 + 4.1588^2} \]

\[ X = 0.43175 \pm 1.8682 \text{ ppm} \]

### Dilution Factor:

\[ 0.43175 \pm 1.8682 \text{ ppm} \times 8 = 3.454 \pm 1.87 \text{ ppm} \]

\[ 3.454 \pm 1.87 \text{ ppm} \times 16 = 55.264 \pm 1.87 \text{ ppm} \]

\[ 55.264 \pm 1.87 \text{ ppm} \times 62.5 = 3454.0 \pm 2 \text{ ppm} \]

\[ 3454.0 \pm 2 \text{ ppm} = \frac{x \text{ (mass of the substance)}}{1000 \text{ mL or g (mass of sample)}} \times 10^6 \]

\[ X = 3.454 \pm 1.87 \text{ mg} \]

### Accounting for entire banana:

Entire banana weighs: 132.382g

Sample Size Weighs: 4.0906g

\[ \frac{132.382g}{4.0906g} = 32.362 \]

Therefore, \[ 32.362 \times 3.454 \pm 1.87 \text{ mg} = 111.778 \pm 1.87 \text{ mg K}^+ \text{ in one Banana} \]
The “true” value of potassium in a banana is approximately 385mg, therefore the amount of potassium calculated does not fall in this range. Although this is true one must take into account the size of the banana. 385mg is for a regular sized banana while the banana size used in this experiment was quite small accounting for the significant lesser value obtained. Also, this calculation was made before standard addition therefore the interference has caused a smaller potassium value. Another factor for the small amount of potassium calculated could have occurred in the extraction phase. The extraction may not have been efficient therefore accounting for the low amount of potassium found.

**Concentration Calculation with Standard Addition:**

<table>
<thead>
<tr>
<th>Concentration (ppm)</th>
<th>Absorbance Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.0456</td>
</tr>
<tr>
<td>2</td>
<td>0.0778</td>
</tr>
<tr>
<td>3</td>
<td>0.1353</td>
</tr>
<tr>
<td>4</td>
<td>0.1548</td>
</tr>
<tr>
<td>5</td>
<td>0.1761</td>
</tr>
<tr>
<td>6</td>
<td>0.2113</td>
</tr>
<tr>
<td>7</td>
<td>0.2399</td>
</tr>
</tbody>
</table>

**Standard Addition Curve**

Potassium in Bananas

\[ y = 0.0318x + 0.0214 \]

<table>
<thead>
<tr>
<th>Coefficient</th>
<th>Standard Error</th>
<th>t Stat</th>
<th>P-value</th>
<th>Lower 95%</th>
<th>Upper 95%</th>
<th>Lower 95.0%</th>
<th>Upper 95.0%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>0.0211443</td>
<td>2.47284</td>
<td>0.05633</td>
<td>-0.00085</td>
<td>0.04373</td>
<td>-0.00085</td>
<td>0.04373</td>
</tr>
<tr>
<td>X Variable</td>
<td>0.008671</td>
<td>1</td>
<td>3</td>
<td>-0.00085</td>
<td>0.04373</td>
<td>-0.00085</td>
<td>0.04373</td>
</tr>
<tr>
<td>1</td>
<td>0.001939</td>
<td>16.4059</td>
<td>1.54E-05</td>
<td>0.026826</td>
<td>0.036795</td>
<td>0.026826</td>
<td>0.036795</td>
</tr>
</tbody>
</table>
Slope = 0.031811 ± (0.001939)
Y-Intercept = 0.021443 ± (0.008671)

\[ x \pm e_x = \frac{b \pm e_b}{m \pm e_m} \]

\[ 0 = (0.031811 \pm 0.001939)x + (0.021443 \pm 0.008671) \]

\[ x = \frac{(0.021443 \pm 0.008671)}{(0.031811 \pm 0.001939)} \]

\[ error = \sqrt{\%e_{x1}^2 + \%e_{x2}^2} \]

\[ x = .6741 \pm .04598 \text{ppm} \]

**Dilution Factor:**

\[ .6741 \pm .04598 \text{ppm} \times 8 = 5.3928 \pm .04598 \text{ppm} \]

\[ 5.3928 \pm .04598 \text{ppm} \times 16 = 86.2848 \pm .04598 \text{ppm} \]

\[ 86.2848 \pm .04598 \times 62.5 = 5392.8 \pm .05 \text{ppm} \]

\[ 5392.8 \pm .05 \text{ppm} = \frac{x \text{ (mass of the substance)}}{1000 \text{ mL or g (mass of sample)}} \times 10^6 \]

\[ x = 5.3928 \pm 0.04598 \text{mg} \]

**Accounting for entire banana:**

Entire banana weighs: 132.382g

Sample Size Weighs: 4.0906g

\[ \frac{132.382g}{4.0906g} = 32.362 \]

**Therefore,** 32.362 \times 5.3928 \pm 0.04598 \text{mg} = 174.5218 \pm 0.04598 \text{mg} K^+ \text{ in one Banana}

**95% Confidence Interval:**

\[ \mu = \text{mean} \pm \frac{ts}{\sqrt{n}} \]

\[ \mu = 174.5218 \pm \frac{3.182 \times 0.04598}{\sqrt{3}} = 174.5218 \pm .08447 \text{mg} \]

The “true” value of potassium in a banana is approximately 385mg, therefore the amount of potassium in a banana does not fall in the range calculated. Although this is true one must take into account the size of the banana. 385mg is for a regular sized banana while the banana size used in this experiment was quite small accounting for the significant lesser value obtained. Another factor for the small amount of potassium calculated could have occurred in the extraction phase. The extraction may not have been efficient therefore accounting for the low amount of potassium found.
Detection Limit
Detection Limits (DLs) are estimates of concentrations at which we can be fairly certain that the compound is present.

\[
\frac{3s}{m} = \frac{3 (.001493)}{.035857} = .1249 \text{ppm}
\]

Due to the fact that the values obtained for the experiment are larger than this number one can assume precise measurements.

Lower Limit of Quantitation
Lower Limit of Quantitation is the smallest amount that can be measured with reasonable accuracy.

\[
\frac{10s}{m} = \frac{10 (.001493)}{.035857} = .4164 \text{ppm}
\]

Due to the fact that both sets of results reveal concentrations larger than the concentration above, one can assume reasonable accuracy.

Conclusion: The amount of potassium found to be in a smaller sized banana was calculated to be 174.5218 ± 0.04598mg after accounting for error in the matrix by performing standard addition. Although the “true” value of potassium in bananas (approximately 385mg) does not fall within the 95% confidence interval range (which was: 174.5218±0.08447mg), one can assume this experiment relevant due to the fluctuating sizes of bananas. The average banana containing about 385mg of potassium is much larger than the banana used in this experiment. From this one can say that the banana used in this experiment would not be a significant source of potassium for human survival. One would need to obtain other sources of potassium in order to reach the 4700mg quota.
Works Cited

