Lab 3 – Finding the Lactose Percentage in Milk

I. Purpose/Objective

For this experiment the purpose was to determine the percentage of lactose in a whole milk sample. This was done with a milk sample and an identically treated blank followed by a titration with Sodium Thiosulfate.

II. Introduction

Milk has been a part of the diet for centuries, and a main component in milk is lactose. Determining the amount in lactose is important for the food industry for many reasons. It can change the composition of how different foods taste, such as cheese, milk, and other dairy products. It is also important to know how it affects the dietary need for calcium. Lactose is a disaccharide sugar composed of glucose and galactose, and is also considered a reducing sugar. In order to determine how much lactose is present in a milk sample, a back titration is used. A back titration is when a solution has an excess of a known standard reagent added to it. This type of titration is normally done when the endpoint of the reverse reaction is easier to determine than a normal titration, for example in precipitation reactions.

For this experiment, an excess of Chloramine-T was used to oxidize the lactose. Since a precipitate forms in the process from the protein and fats haven been separated out, using a back titration is the best form to use. To test the lactose and its end point, a blank with water as the replacement was used. Both samples were then titrated with sodium thiosulfate, and the total volumes of the blank and the lactose samples could then be used to figure out the end point of lactose.

III. Procedure

The procedure used for the experiment can be found in “Principles of Food Composition Laboratory Manual” (2013) Experiment 4, Lactose in Milk, pages 33-36. The modifications for this experiment included that the whole milk used had 0.05 g of sugar per mL of milk. The next change was that the milk and blank solutions were put into conical 50 mL tubes instead of 50 mL volumetric flasks. Once all the reagents were added, both mixtures were shaken well and then left undisturbed for more than 10 minutes. Another modification was that once the lactose and blank
solutions were added into 4 smaller Erlenmeyer flasks, they were wrapped up in foil and then left to sit for 60 minutes, not 90 minutes. Lastly, the final modification was to add 10 drops of the starch indicator after a light yellow was observed.

IV. Data/Results

(Table 1) Starting and end volumes of titrant added to water blanks and milk samples, includes initial & final volumes in mL of titrants for each duplicate.

<table>
<thead>
<tr>
<th></th>
<th>A = Lactose</th>
<th>B = Blank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start:</td>
<td>A1</td>
<td>A2</td>
</tr>
<tr>
<td></td>
<td>0.25</td>
<td>17.35</td>
</tr>
<tr>
<td>Stop:</td>
<td>17.35</td>
<td>34.55</td>
</tr>
<tr>
<td>Total:</td>
<td>17.10</td>
<td>17.20</td>
</tr>
</tbody>
</table>

(Table 2) Shows calculated total volume of titrant used for each duplicate, and calculated concentration of lactose in milk filtrates all in mL.

<table>
<thead>
<tr>
<th></th>
<th>Average Titrant</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>17.10</td>
<td>24.60</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>17.20</td>
<td>24.69</td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td>17.15</td>
<td>24.65</td>
<td></td>
</tr>
</tbody>
</table>

Average Milk Concentration in filtrate: 0.027 M
Calculated g of lactose/mL: 0.052

(Table 3) Milk carton labeling information, calculated amount of fat and protein in 25mL milk, true volume of the filtrate, the density information of milk fat & protein, and a comparison of the calculated g lactose in milk vs. the label.

<table>
<thead>
<tr>
<th>Amount in grams:</th>
<th>Milk Sample</th>
<th>Carton Label</th>
<th>mL in Milk Sample</th>
<th>Density of Milk Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protein</td>
<td>0.80</td>
<td>0.32</td>
<td>0.64</td>
<td>0.032</td>
</tr>
<tr>
<td>Fat</td>
<td>0.86</td>
<td>0.32</td>
<td>0.96</td>
<td>0.034</td>
</tr>
</tbody>
</table>

V. Calculations

- Amount of fat in 25 mL milk (mL)
  
  3.5% wt/vol x 25 mL milk = 0.88 g fat
  
  0.88 g fat x 1.1 mL/g fat = 0.96 mL fat
• Amount of protein in 25 mL milk (mL)
3.2 % wt/vol x 25 mL milk = 0.80 g protein
0.80 g protein x 0.8 mL/protein = \textbf{0.64 mL of protein}

• Amount of filtrate, which contains lactose (mL)
50 mL – 0.64 mL protein – 0.96 mL fat = \textbf{48.4 mL of filtrate that has lactose}

• Concentration of lactose in filtrate (g lactose / mL filtrate)
\[
A = \frac{(Tb-Ts) \times (N/2) \times 342}{5 \times 1000}
\]
A = g lactose per ml filtrate
Tb = average titration value for blank (mL)
Ts = average titration value for sample (mL)
N = normality of Na2S2O3
342 = molecular weight of lactose

\[
A = \frac{(24.65-17.15) \times (0.1/2) \times 342}{5000} = \textbf{0.027 g/mL}
\]

• Concentration of lactose in milk (g lactose / mL milk)
g lactose/mL milk = \frac{A \times B}{25}
\[
= \frac{0.27 \times 48.4}{25} = \textbf{0.052 g/mL}
\]

VI. Discussion

The results of this experiment show that for the whole milk sample, there was around 0.052 grams of lactose/mL. Which is a close to the 0.05g of sugar that was calculated being in the milk sample from the label. Both of the titrating volumes were also in an accurate range. The purpose of the blank is to become a standard volume to compare against the volume of reacted lactose. Therefore, it took longer to titrate the blank than the lactose. The blank had a total average volume of 24.65 mL of sodium thiosulfate. Whereas the milk sample only took a total average of 17.15 mL in order to reach its endpoint. By using both of these observed volumes, the concentration of the milk in the filtrate could then be determined, which was 0.027g/mL. This calculation can then be used in order to find the amount of lactose in milk, which was 0.052
g/mL. It can also be noted that the color changes happened much quicker when the milk sample was titrated. It took 7.50 mL more of thiosulfate to go through all the color changes with the blank than the milk.

When comparing the amount of lactose in the milk sample and on the label, there are differences. The milk sample has more fat, protein, and lactose than what the label says, which can be seen in Table 3. This could probably be due to the fact that some of the lactose collected isn’t physiologically digested and is insoluble. Since the body does not absorb some lactose, the label does not have to include that fraction of lactose.

VII. Conclusion

The purpose of this lab was to understand the method of back titration while determining the amount of lactose in milk in the process. Back titrating was a good method to use for this experiment because after the endpoint of the blank was determined, there was a range of how much titrant we should approximately use for the lactose. By doing this, the total volumes could be calculated in an efficient manner, and then used to determine how much lactose was in the milk sample. This type of method is important because the food industry can use this to create different types of milk (fat free, 1%, 2%, whole, etc.), which they currently have been doing. The only improvement that could be done would be to try to lower the amount of waiting time for the chemical reaction of the Chloramine-T solution and reagents, but if it can’t be shortened to less than an hour it is understandable.

VII. Questions
1. Chloramine-T is very reactive and is a useful blank solution when used in lactose determination because it shows the amount of Chloramine-T that can react. By knowing the amount that can react, you can then use back titration for the lactose solution.
2. The data that was collected from the milk sample fell fairly close to the milk label however there were some discrepancies. In table 3, it can be seen that the milk sample had a higher amount of both fat and protein compared to the label. There was a 0.48g difference in the protein, and a 0.54g difference in the fat. For lactose, the values were closer. The milk sample had 0.057 g/mL of lactose, and the milk label had 0.05 g/mL of sugar – the sugar would be referring to lactose.