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H Bio. per. 3
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Buffering Abilities of Biological and Abiotic Solutions after Addition of Acids and Bases

Lab Partners
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Purpose
To determine the degree to which the pH of various homogenates derived from living organisms (milk, egg white, potato, and gelatin) changes with the addition of first an acid (0.1M HCl) and then a base (0.1M NaOH), as compared to tap water (a control) and a pH 7 buffer solution (a second control).
Copied from lab assignment sheet.

Independent Variable: solution - biological (milk, egg white, gelatin, potato), artificial buffer, water
Dependent Variable: change of pH when acids and bases added

Hypothesis
If we add 30 drops of an acid (0.1M HCl) and a base (0.1M NaOH) to a biological solution (milk, egg white, and gelatin), tap water, and a pH 7 buffer solution, *then* the buffer solution will resist the changes in pH the most, then the water because it is so essential to life, and then all of the biological solutions, with milk having the least buffering ability because it is not very important to life.

Materials
- 50mL beaker
- 1 glass stirring rod
- 1 forcep
- 70* wide range pH paper
- 25mL jar of acid (0.1M HCl: hydrochloric acid) and dropper*
- 25mL jar of base (0.1M NaOH: sodium hydroxide) and dropper*
- 50mL pH 7 buffer solution
- 50mL tap water
- 50mL milk
- 50mL potato (blended)*
- 50mL egg white
- 50mL gelatin suspension

Copied from lab assignment sheet. (* = modified)

Safety Considerations
Wearing goggles, wearing an apron, and tying back long hair is recommended during this experiment. Note that 0.1M HCl and 0.1M NaOH are both mild irritant. Avoid skin/eye contact; do not ingest. If contact occurs, flush affected area with water for 15 minutes, rinse mouth with water, and call your teacher. After the experiment, wash down lab bench and wash hands to ensure no harmful acid or base remains.
Copied from lab assignment sheet.

Procedure
1. Pour 25mL of tap water into a 50mL beaker.

2. Find the initial pH of the water using the pH paper: Use the forceps to dip the small strip of pH paper into the water and compare the color change to the standard color chart. Hold the pH paper in the water for three seconds, and then wait for three seconds before comparing the colors.*
3. Record the indicated pH onto the data table.*
4. Add hydrochloric acid to the water one drop at a time. Use the glass stirring rod to stir the contents of the beaker each time a drop has been added. Determine and record the pH after 5 drops has been added.
5. Repeat the procedure (step 5), measuring and recording the pH after every 5 drops, until 30 drops in total has been added to the tap water.
6. Empty the content of the beaker in the sink. Rinse the beaker thoroughly.
7. Pour into the beaker the remaining 25mL of tap water. Repeat steps 1-5 with the sodium hydroxide (base) instead of the hydrochloric acid.
8. Test and record data for each of the biological materials listed (milk, egg white, potato, gelatin) and the buffer solution (instead of tap water) by repeating steps 1-6.
9. Collect data from other groups (within and outside of current class if necessary). Compare them- look for any major differences, and general similarities.*

Copied from lab assignment sheet. (* = modified)

Data (attached, next page)

1. **Full Results Data Table**
   This is the data collected by our group and a few other groups from other classes.

2. **Averages Data Table**
   This is the averages of all the data to easier see which solutions were better buffered the change in pH. Because the changes in the pH after the addition of both acids and bases in each solution were pretty similar (relative to the difference between the solutions), I decided to average the changes of the solution after the addition both acids and bases and report the changes in an average of change of pH per drop of acid or base added.

3. **Ordered Averages Data Table**
   This is the averages of all the data, but is ordered from least to greatest buffering capability and better shows the how all of the biological solutions have a higher buffering capability than water

4. **Sources of Data**
   This shows the sources of our data.

5. **Chart**
   This is a chart of the averages of all of the data, to visually show the results.

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Analysis (Results)

According to the averages of multiple groups' results, the buffer solution resisted pH changes the best, averaging a change of only 0.018 pH units after a drop of acid or base; second was the milk with an average change of 0.063; third was the egg white, with an average change of 0.081; fourth was the potato, with an average change of 0.112; fifth was the gelatin, with an average change of 0.14; the solution to buffer the changes in pH the least was the tap water, with an average change of 0.158. The artificial buffer buffered the best as expected; the biological solutions (milk, egg white, potato, and gelatin) were close behind in their buffering ability; the tap water allowed for the greatest changes, almost nine times that of the artificial buffer and over 1.5 times the average of the biological solutions.

Conclusion

Based on the results, I can confidently conclude that the biological solutions that we tested, besides water, are buffers- that they resist changes in acidity such as our additions of acids or bases to the solutions. Our experiment showed that the tap water's pH changed the most, with a total increase of 3 on the pH scale when we added 30 drops of sodium hydroxide, and a total decrease of 4 on the pH scale when we added 30 drops of hydrochloric acid. On the other hand, the pH of the milk, gelatin, potato, and egg white increased by 1, 4, 2.5, and 3, respectively, when we added the base and decreased by 2, 2, 2.5, and 3.5 when we added the base; all of these values save the addition of a base to the gelatin solution were less than water- this shows that they change less after the addition of acids and bases, showing a better buffering capability. The results from the other groups had very similar data to ours, providing more evidence for my conclusion. Actually, many of the other groups had found a similar amount of change of the biological substances but an even larger amount of change in the water- this better shows that water is not a buffer but the other substances created by organisms are.

My conclusion did not support my hypothesis that the tap water would best resist changes in pH (besides the buffer solution), and that the milk would change the most. I had thought this because water makes up so much of all of our cells (approximately 70%), so any change of acidity in the water of our cells would be buffered; and I had thought that the milk was not very essential to life, much less than water, so I assumed that it would contain buffers. Instead, the results showed that milk resisted the change in pH the most (besides the buffer solution), followed by the gelatin, the egg white, and lastly the water. This is the opposite of what I had hypothesized.

This conclusion makes sense, because the biological substances are all common in the body and should keep their acidities constant so that their proteins would keep their functional shape, so they have various buffers; we learned from class that the shape of proteins is critical, and an abnormal pH could affect it. We also learned in class that water cannot be a buffer, because it is not (chemically) made up of an acid or base; finally, we learned that the water of cells usually contain natural buffers, such as the amino acids of proteins- this validates our conclusion.

Reflection (Comments)

In our experiment, there were few possible sources of error, but we were still confident with the validity of our results and conclusion. We followed all of the directions, although we may have rushed a little bit during the experiment, and our group finished first. Although our data doesn't show too much difference from the other groups', there are some minor changes (that do not affect our conclusion): our tap water changed the least of all the groups. After averaging out our groups' data with some other data, my conclusion is more valid because there is a larger gap between the change in pH of the tap water and the change in pH of the biological solutions- the extra evidence creates a stronger claim that the buffering capabilities of the biological solutions are greater than the water.

To enhance this experiment, we should use biological solutions that are more essential to life, such as blood, or gastric fluids, or tree sap. Without these solutions having a regulated acidity, some organisms could not exist, or will have disorders (as opposed to the liquids we tested) - this would further validate my conclusion that *essential*-to-life fluids will have buffers. If we conduct a similar experiment again, testing these liquids will provide additional evidence to show that important biological substances need to have buffers for organisms to survive.