CHEMISTRY EXTENDED ESSAY

“*Investigation on Rosehip Fruit Tea, Linden Herbal Tea, Sage Herbal Tea and Green Tea-are thay acidic or not?*”

Name: Hazal Kutluk

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Supervisor: Serenay Tarhan Güler

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TED Ankara College Foundation High School

ABSTRACT

Tea is a widely-consumed daily life product, which is claimed to be very advantageous for health. But it may have negative effects on health, too. Consuming tea with a hungry stomach causes stomachache, and doctors say that this is because the tea is acidic. *This investigation aims to determine if four types of teas (Rosehip Fruit tea, Linden Herbal Tea, Sage Herbal Tea and Gren Tea with Lemon) are acidic or not.*

This investigation is important in the sense that the way the tea is consumed may be limited. Determining if the tea is acidic or not may effect the habits of many people about tea consumption. In order to determine if the tea is acidic or not, I used the titration method. Titration is a technique in which the molarity of a solution can be found by using a strong base or acid with a known molarity and volume.

At the end of my trials, I found out that these four types of teas are all acidic. These results showed me that Rosehip Fruit Tea is the most acidic one among all, and the Linden Herbal Tea is the one closest to the neutral. When an order is made between the acidities tea types, I reached to the conclusion below:

Rosehip tea > Green tea with Lemon > Sage tea > Linden tea

Word Count: 224

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INTRODUCTION

I love to drink many types of tea, and to drink tea is something I do every morning, even without eating something for breakfast. The kinds of tea I love to drink are mostly the rosehip fruit tea and the linden herbal tea, while I like to drink sage herbal tea or green tea, too. After a few years since too often tea drinking -especially rosehip tea drinking- became a habit for me, I started to suffer from stomachaches, which in the end led me to a doctor. The doctor found the cause in the tea, since I've been drinking it too much and each morning without even eating something, the teas I used to drink has been damaging my stomach. How could that happen, I wondered, which led me to make a small investigation on these kinds of tea I've mentioned, becoming the subject for my extended essay.

When we think about the tea, it is not that hard to realise that it is a widely-consumed kind of drink all around the world. Today, tea is being produced over 30 countries and consumed worldwide, and it said to be widely consumed beverage aside from water with a per capita worldwide consumption of approximately 0.12 liter per year. There are lots of types of tea, including thousands of herbal ones and fruit tees, black, white and green tea, and tea has taken place in almost every culture. With this point of view, I personally thought that it is important to find out if the tea is acidic, as tea consumption may have unpleasant consequences such as in my case. The tea types I will work with will be: Linden Herbal tea, Sage Herbal tea, Green Tea with lemon and Rosehip Fruit tea, as these kind of teas seem to be mostly-consumed kind of teas after the black tea itself. I didn't make a research on the black tea, because I don't consume it at all and considering my case, I thought it may be better to make an investigation on the teas I am used to drinking, as the doctor had implied that my stomachache is due to consuming these teas too much.

What we call as tea is actually the leaves of the plants, which are being picked in some specific seasons and then dried up. There are many types of tea such as white, green and black tea, these are all obtained from the leaves of the plant Camilla Sinensis. The reason why the colours or the tastes of these kind of differ is that the laeves of Camilla Sinensis is differently treated during the tea production processs. In some cases, the way Camilla Sinensis is being grown also differs.

Green tea differs from black tea in the sense that black tea is being fermented, but green tea is not. The leaves of the plant Camilla Sinensis are picked up and withered. Withering is the process that enables the leaves dry up to 70%. Leaves are laid over a surface, letting the air in. This results in reducing in the moisture. The next step is the rolling of the leaves, which gives the leaves a shape and also lets the leaves break and open up. When the leaves are opened up, the enzymes in the leave react with the air, causing oxidation. This is the step which makes teas differ from each other, named as fermentation step. Black tea, for instance, is completely oxidised while green tea is not let to be oxidised at all. The more oxidation takes place, the darker is the tea. During this process, the leaves change colour from green to brown and this is why black tea has the name black and green tea has the name green. When the oxidation process is over, the leaves are dried up in such a way that no more oxidation with the air can take place, because there is no water left in the leaf for the chemical processes to occur. In the fermentation of the tea, despite the name of the process, no bacteria or any other microorganisms are used, just chemical reactions take place.

Fruit teas and herbal teas, on the other hand, are not made up of the leaves of Camilla Sinensis. Rosehip tea is made up of the leaves and the fruits of rosehip, for instance. The same goes with the linden and the sage teas. As their name indicate, their source is their own plants, with leaves and fruits, flowers also. These leaves and fruits do not go under the same process with black or green tea, but it is similar. The way the herbal or fruit teas produced is a process called infusion or tisane of the leaves, flowers or herbs. In this process, the leaves are better dissolving in water, therefore when the dried herbs, flowers or fruits meet with the boiling water, they have a tendency to leave their ingredients to the water.

When we think about the plant structure, basically we know that the plants include many organic acids such as fatty acids or amino acids. Amino acids, which are the units of proteins, must be found in any cell as the enzymes area necessity for being alive and they are made up of proteins. These are the main elements right now I can think of which may cause the tea being acidic, as I have indicated that what we call is tea is the leaves of a plant.

But is tea really acidic? This may be a too broad question to make an investigation of each type of tea, but when the question is asked for four types of tea, it is not.

Therefore my research question is shaped as: Are the Rosehip fruit tea, Green Tea with Lemon, Sage Herbal Tea and Linden Herbal Tea acidic?

To achieve my purpose, I chose to use the method called titration, which is a process for determining the pH of a solution. Just using my empirical experience of the stomachache I suffered from, my hypothesis is that the four kind of teas I will investigate on will turn out to be acidic.

PLANNING AND DEVELOPMENT

To be able to determine the pH of any substance, titration seems to be a possible way. While investigating the pH of the herbal teas, I chose to use the method titration.

Variables

Independent variables: Molarity of NaOH in the burette, volume of the solution which will be titrated.

Dependent variables: Volume of the NaOH used in order to titrate the solution, Molarity of the solution which will be titrated.

Controlled Variables: Pressure and Temperature of the medium. I finished all my trials in one day, because I wanted to keep the temperature and the pressure stabilized.

Materials:

- 750.00 ± 0.10 mL 0.01 M NaOH, 700 mL 0.05 M NaOH
- 15 unit packages of each type of tea (rosehip fruit tea, sage herbal tea, linden herbal tea, green tea) *(refer to Pictures 1,2,3,4 in Appendix)
- 10500.00 ± 0.10 mL of pure water
- A kettle (Severin, 2200 watt)
- A chronometer (Nokia 6300 chronometer is used in these trials)
- Apparatus for titration (2 burettes, with the volume of 50.00 ± 0.05 mL) In one of the burettes there is 0.05 ± 0.01 M prepared NaOH and in the other there is 0.01 ± 0.01 M prepared NaOH.
- 4 beakers, with a volume of 250 mL
- A thermometer, (-10°C – 110°C)
- Phenolphatelein
- A barometer (hPa)

Preparing NaOH solutions

In the lab, I didn't have 0.05 M or 0.01 M NaOH but 2 M. To obtain 0.05 M and 0.01 M NaOH, I made the below transformations:

At first, I didn't know how much 0.05 M or 0.01 M NaOH in amount I would need, because I had no idea how acidic the teas are. So I started assuming that in the whole experiment I would need 500 mL of 0.05 M NaOH and 500 mL of 0.01 M NaOH. Therotically:

0.05 M NaOH * 500 mL = 2 M NaOH * x mL

From this equation, x is found to be 12.5 mL.

I added 12.50 ± 0.10 mL of 2.00 ± 0.01 M NaOH into a 500 mL beaker and added up pure water up to the level 500.00 ± 0.10 mL, therefore I was able to obtain 0.0500 ± 0.0090 M of NaOH.

To prepare 0.01 M NaOH, theoratically:

0.01 M NaOH * 500 mL = 2 M NaOH * y mL

From this equation, y is found to be 2.5 mL.

I added 2.5 ± 0.10 mL of 2.00 ± 0.01 M NaOH into a 500 mL beaker and added up pure water up to the level 500.00 ± 0.01 mL, therefore I was able to obtain 0.0100 ± 0.0005 M of NaOH.

As I ran out of 0.05 M NaOH, I repeated the same steps in order to transform 2 M NaOH to 0.05 M NaOH. During my experiment, I repeated this process 2 times, and in the end I had 300 ± 0.10 mL extra of 0.0500 ± 0.0090 M NaOH.

I repeated the same steps for obtaining 0.01 M NaOH too, and as in obtaining 0.05 M NaOH, I had to repeat the same process 2 times and in the end I had 250± 0.10 mL mLs extra of 0.0100 ± 0.0005 M NaOH.

Procedure:

1) I poured 700 mLs of pure water in the kettle and placed a thermometer in the water while heating it so that I could measure the temperature of the water.
2) After heating about four and a half minutes, the temperature will be approximately 92.00^{o}C ± 0.05^{o}C, when the thermometer reaches to 92.00^{o}C ± 0.05^{o}C, I shut the kettle down immediately. With the effect of the heat, the temperature will rose up a few cantigrades more, being approximately 95.00^{o}C ± 0.05^{o}C.
3) I poured 150.00 ± 0.10 mL s of pure water into each 250 mL volumed beaker, and poured down the rest of the water which stays in the kettle, leaving the kettle for cooling down.
4) I open up one unit package of each type of tea, left the tea bags into the boiling 150.00 ± 0.10 mL water, each within same time. At this time, I started the chronometer and waited for 5 minutes.
5) While waiting, I shaked the tea bags in the water a little bit so that the brewing tea can be better diffused in water.
6) When 5 minutes are over, I took the the tea bags out of the water and I have done with them.
7) I waited for one minute for the beakers to cool down so that I could hold them during titration.
8) Firstly, I took the beaker which included sage tea in it. I dropped three drops of phenolphatelein in it.
9) Sage tea had a light brown colour (refer to appendix, pictures). I have titrated the sage tea with my prepared 0.0100 ± 0.0005 M NaOH solution and recorded my values. The reason why I made the titration with 0.0100 ± 0.0005 M NaOH is because, when I did the titration with the 0.0500 ± 0.0090 M NaOH, I had obtained very small numerical values. To be more precise about my results, I had to obtain bigger numerical values and due to that I reduced the molarity of the NaOH .
10) When sage tea is at the neutralising point, it turns into very dark brown. (refer to appendix, pictures)
11) When my titration with sage tea ended, I poured the sage tea solution into the sink and washed up the beaker with pure water. (the amount of pure water

needed for cleaning process after each trial is not included into the amount of pure water in the material list.)

12) After that, I took the beaker which included green tea with lemon and repeated titration and recording. When I preferred to use 0.0100 ± 0.005 M NaOH with the green tea, I had to use a huge amount of NaOH, due to that reason I changed the molarity of the NaOH used, to 0.0500 ± 0.0090 M NaOH. Green tea with lemon at the beginning has a yellow colour. At the neutralisation point, the solution turns to reddish-brown. I recorded the values I obtained.
13) When my titration with the green tea has ended, I repeated step 11.
14) The third beaker to be titrated is the one with rosehip tea in it. Rosehip tea had a colour of dark red, and it was hard to observe the colour change so I was very careful about any little colour change. For the same reason with green tea, I used the 0.0500 ± 0.0090 M NaOH to titrate rosehip tea solution. At the neutralising point, the solution becomes very dark red, almost blackening.
15) When rosehip tea titration ended, I recorded my values and repeated step 11.
16) The last beaker to be titrated is the one with linden tea in it. For the same reason with sage, I used 0.0100 ± 0.0005 M NaOH to titrate linden tea. Linden tea has a colour light yellow, very light that merely transparent. At the neutralising point, it had turned into a reddish pink.
17) When my titration with the linden tea ended, again I recorded my values and repeated the step 11.
18) I made 15 trials, which means I have repeated the steps 1-17 15 times.
19) During this process, I made sure with using a thermometer and a barometer that the pressure and temperature is constant. To do this, I made all my trials in one day and the room temperature was 23°C and I was alone in the lab, no one had opened any door ar window, therefore there was no change in pressure or temperature.

Calculations for Titration:

At the colour changing point, we assume that the solution is just neutralised.Thus, the amount of acid in the solution is equal to the amount of base in the solution.

The amount of base = The amount of acid

‘n’ moles of base = ‘n’ moles of acid

$$M\ (molarity) = \frac{n(number\ of\ moles)}{V\ (volume)}$$

$$n = M * V$$

molarity of the base*volume of the base = molarity of the acid*volume of the acid

$M_{base}*V_{base} = M_{acid}*V_{acid}$

From the above equation, M_{acid} can be found, which I was looking for.

M_{base} indicates the molarity of the strong base NaOH, which is 0.0500 ± 0.0090 M when experimenting with rosehip and green teas and 0.0100 ± 0.0005 M when experimenting with the linden and the sage teas.

V_{base} indicates the volume of the NaOH (can be taken in mL). It may be found by using the mL lines on the burette.

V_{acid} indicates the volume of the solution, which is the tea solution before titration, assumed to be 150.00 ± 0.10 mL. (as V_{base} value is obtained in mL, this value should also be in mL, so that the units may cancel each other.)

M_{base}*V_{base} =M_{acid}*V_{acid}

M_{base}* A mL = x M * 150 mLuncertainity zorlanırsan

$$x\ M = \frac{\text{Mbase} * A\ mL}{150\ mL}$$

mL s cancel aech other in the above equation, thus:

$$x\ M = \frac{\text{Mbase} * A}{150}$$

<u>This experiment will search for the values ‘A’, thus x can be calculated.</u>

What happens after x is calculated?

If one knows the molarity of an acidic or a basic solution, the pH of the solution is calculated within the below equation:

$$pH = -\log[H^+]$$

Here, the brackets ‘[ ]’ indicate molarity. Thus:

$$pH = -\log(M_{acid})$$

$$pH = -\log x$$

Using these equations, my aim is to calculate the pH of the rosehip fruit tea, sage and linden herbal teas and green tea with lemon.

Data Collection and Processing:

	The amount of 0.01 M NaOH used in order to obtain a change in colour (value A) (mL) ± 0.10		The amount of 0.05 M NaOH used in order to obtain a change in colour (value A) (mL) ± 0.10	
Number of Trials	Sage Herbal Tea	Linden Herbal Tea	Rosehip Fruit Tea	Green Tea with Lemon
1	16.10	10.00	23.20	11.10
2	17.00	8.20	22.00	10.60
3	15.70	9.70	24.30	12.90
4	15.10	13.00	21.90	9.80
5	17.50	9.90	23.20	10.90
6	17.10	10.80	27.30	11.80
7	15.00	11.60	22.80	10.50
8	16.60	9.90	25.20	11.90
9	15.90	12.10	26.30	12.00
10	18.10	8.90	25.40	9.90
11	17.40	12.00	23.60	10.30
12	17.60	11.30	23.20	11.90
13	16.90	9.90	24.20	11.70
14	15.70	10.00	21.90	10.80
15	16.80	12.30	23.50	11.30

Table 1: the amount of NaOH used in order to neutralise the tea solutions

There is a significant change between the colours of teas before an after being titrated. Sage Tea is firstly light yellow but after being titrated it is dark brown. Linden tea has a very light yellow colour, which is nearly transparent but after being titrated, it turns into a reddish- pink coloured solution. Green Tea with lemon is at the beginning yellow but in the end it turns into reddish_brown. Rosehip Tea is dark brown before titration, and after the process it becomes almost black. (Refer to Appendix, Pictures.)

To make a pH calculation, the average amount of the strong base used in order to neutralise the solution is needed. The calculations take place in the Appendix part.

	Sage Herbal Tea	Green Tea With Lemon	Rosehip Fruit Tea	Linden Herbal Tea
pH of the tea (±0.01)	2.96	2.43	2.10	3.14

Table 2: pH of the teas

CONCLUSION AND EVALUTION

In this experiment, I came to prove that tea is an acidic drink.

My doctor was right to tell me that I should stop drinking tea too much, because drinking acidic drinks too much may hurt the stomach, as in my case.

The results I have obtained is shown as follow:

pH of the rosehip fruit tea: 2.10 ± 0.01

pH of the green tea with lemon: 2.43 ± 0.01

pH of the sage herbal tea: 2.96 ± 0.01

pH of the linden herbal tea: 3.14 ± 0.01

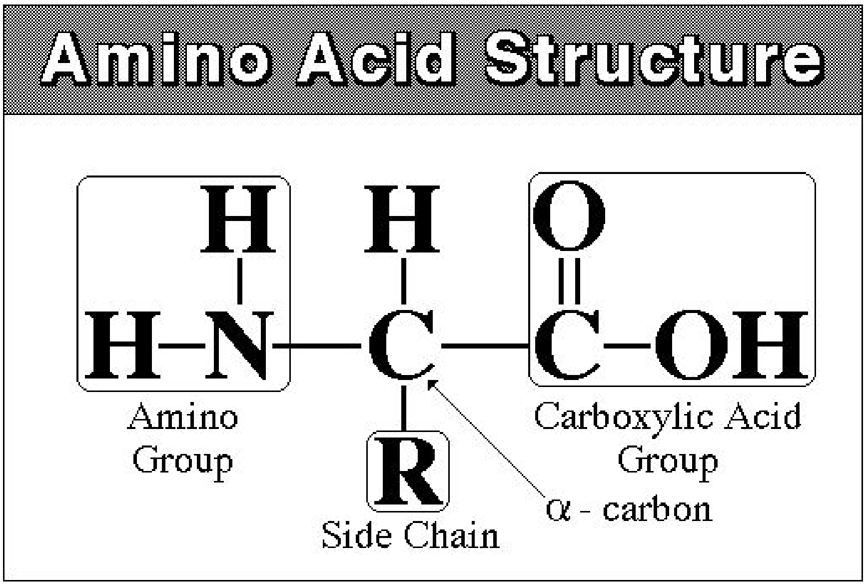
As the pH value of an acid gets bigger numerically, this means that the acid is weakening. Up to the value 7, the solution is acidic. At pH value of 7 the solution is neutral an between the values 7-14, the solution is basic.

According to the results I have obtained, when the acidic strengths of the teas are compared, the sequence is this:

Rosehip tea > Green tea with Lemon > Sage tea > Linden tea

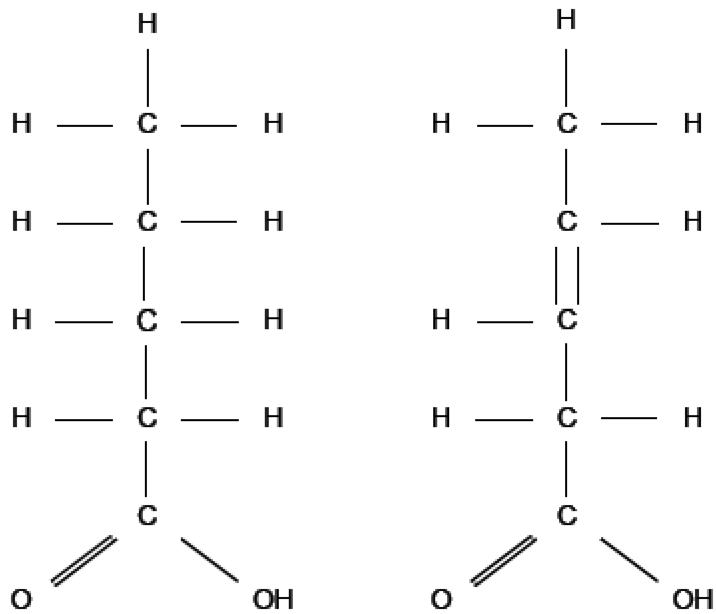
My hypothesis is proved to be true, but I was curious about the reason why, the tea is acidic. This led me to make an investigation on the structure of tea.

First of all, I was right to think that the tea includes varying acidic structures, such as amino acids. In the leaves of any plant, 20 kinds of amino acids are certainly found. As their name indicate, they have the effect of acidity.



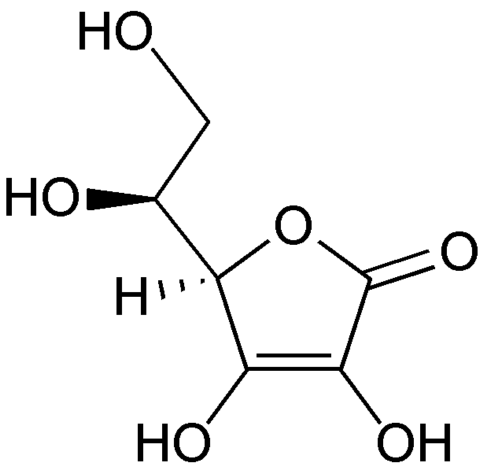
Picture 10: the structure of amino acid

Another organic acid which is found in the tea is fatty acids. Fatty acids, combining with glycerol, form the fats. As the plants can store fats, fatty acids are found in their cells, causing acidic effect.



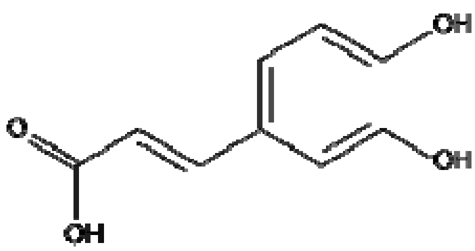
Picture 11: Fatty acid structure

In green tea and rosehip, there is a lot of vitamin C in amount. As the green tea I was experimenting with also included lemon tree leaves besides green tea itself, the amount of vitamin C is certainly upgraded. Vitamin C may be an important element causing rosehip tea and green tea being more acidic then sage and herbal tea, because in my research I found out that neither sage nor linden leaves were found out to be having a critical amount of Vitamin C. Vitamin C is sure to have an acidic effect, as the other name of the vitamin C is L-ascorbic acid. Among the four kinds of teas, rosehip is the one which includes the most vitamin C in amount.

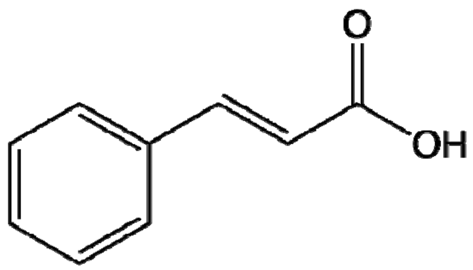


Picture 12: the structure of vitamin C

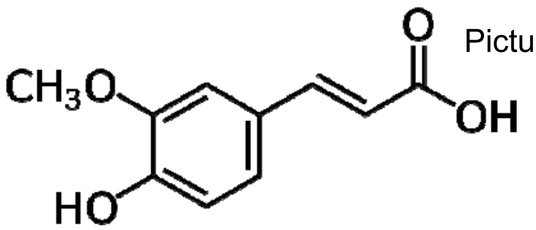
Another element causing acidity is the polyphenols, found especailly in green tea. Polyphenols are structures which include many phenols, and found in plants. One of the polyphenols is a structure called tannin, and the basic unit of a tannin is gallic acid. Lignin is another polyphenol structure, which is a supporting tissue for the plant. The base unit of the lignin is cinnamic acid. Polyphenol structures also include acids such as cafeic and ferulic acids.



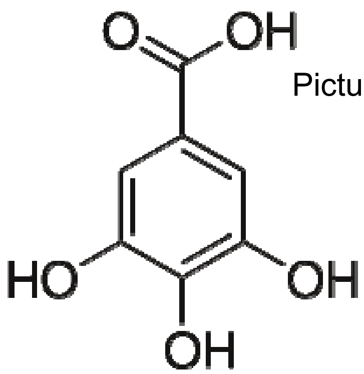
Picture 13: the structure of caffeic acid



Picture 14: the structure of cinnamic acid



Picture 15: the structure of ferulic acid



Picture 16: the structure of gallic acid

- In each trial, I preferred to boil 700 mL of water instead of 600 mL of water, because while boiling, some of the water is evaporated. Thus I would not be able to pour 150 mL of water into each beaker to prepare teas. Although I tried hard to stabilize the amount of water in the beakers, while the teas were being steeped, some amount of the water evaporated. This may cause an error, because due to evaporation the volume of the solution is not 150 mL, but assumed to be 150 mL. This is why we make an assumption when calculating the molarity of the solution.
- The amount of herbs the tea packages included were not the same, and finding the same amount herb-including tea packages was not possible. This may cause an error. We won't know if we have the most accurate results, because we don't have an idea of the ability of any herb to diffuse in water. If linden herbs were in the same amount with the sage, the result maybe that they have the same pH value. Maybe 1 gram of linden herb includes the same amount of acidic structures with 1 gram of sage herb, but as the amounts of the herbs in the packages differ, the amount of acidic structures diffusing in the water may be different, resulting in different pH values. It would be better if I could find tea packages including same amount of herbs in them. Maybe I could go to some shops selling natural herbs and I colud buy some sage, linden, rosehip and green tea in the same amount, but as my aim was to test the teas being sold in the market, it wouldn't be proper.
- Titration is a method which includes mostly perception. Beside the optical errors such as not being able to read the liquid level in the burette, one should be very careful about the moment the solutions change colour. In my experiment, my solutions were already coloured, and especially it was very hard to determine the colour change in rosehip tea. Although I was very sensitive about the colour change so that the error is minimized, I still think that this situation is a factor of error. An alternative way to minimize this kind of error may be pH meter usage, but I didn't have any well-calibrated pH meters available thus I couldn't use a pH meter. If I had used a well-calibrated pH meter, I could identify the exact point that the teas were neutralised, thus there would not be any error due to the difficulties in examining the colour change of the solutions.

- I have indicated that I have prepared from 0.05 M and 0.01 M NaOH two times. When preparing the solutions, I might have done very small changes in amounts, therefore the secondly prepared 0.01 M NaOH may not be the exactly same with the firstly prepared one. The same thing goes with the 0.05 M NaOH solutions. This situation, although I was very careful with the amounts, because of the syntax error, may be a source of error.
- Although I tried to keep the temperature and the pressure constant, because of the daily temperature difference these values may have changed very little. I think I would have more accurate results if I had 14 co-experimenters with me and enough material so that each trial would be done in the same timing.
- For further investigation, one could examine the amount of amino acids or any other acids stated in the conclusion part and the effects of these acids on the acidities of the teas. How much effective are the amino acids in the acidity of rosehip? Or what about vitamin C? I myself think that the main effect which made rosehip tea most acidic one among other types of teas are the amount of vitamin C the plant rosehip has. This may be a good point to experiment on.

After this investigation, I am now warning the people around me about not to drink teas with a hungry stomach, especially the rosehip fruit tea. In this way now I can combine my experiment with daily use, and with the benefits of the society.

APPENDIX

Method of Titration:

Titration is a technique which enables one to calculate the molarity of an acid or a base with using a acid or base of a known molarity.

In titration, there is a thin pipe with numbers on it, named as burette. These numbers indicate the amount of mililitres. In burette, there is the strong acid or base with known molarity. In this experiment this substance which will take place in the burette is the 0.0500 ± 0.0090 M NaOH, when trying to find out the molarity of the rosehip tea and the green tea, and is 0.0100 ± 0.0005 M when experimenting with the teas linden and sage. If there is a strong acid in our burette, this means that we are testing our solution for being basic. If there is a strong base in our burette as in this experiment, this means that we are testing our solution for being acidic.

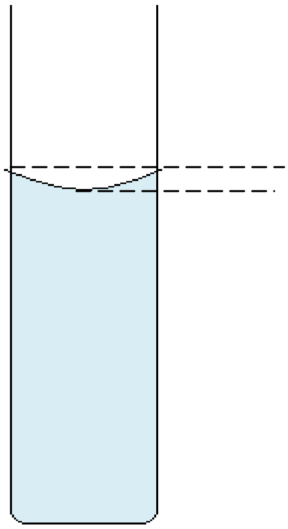
Into a beaker, the solution which will be titrated is put. To be able to get a result, we shall know the volume of the solution we put into the beaker. In this experiment the solutions are the four types of brewed teas, which take place in the beakers, each assumed to be having 150 mL of volume *(Considering why that we make an assumption here, refer to the section 'Conclusion and Evaluation'). Right now the values we have are the volume of the solution which will be tested and the molarity of the strong base we will use in order to titrate the solution.

After telling about the background information, we can talk about the method and the aim of titration. In titration, our aim is to find the molarity of the solution titrated, as I have indicated before. To be able to do this, titration method benefits from the acid-base neutralisation reactions. When an acid and a base reacts, they neutralise each other, and when the amount of acid in the solution is equal to the amount of base in the solution, a complete neutralisation takes place, the pH of the solution becomes 7.0. In order to understand that a solution is changing from being acidic to being basic or from being basic to being acidic, we use some chemical substance called indicators. Indicators cause the solution being titrated change colour so that we can understand that neutralisation had just taken place and the solution is changing character. In this experiment I will use phenolphatelein as an indicator, an indicator which changes colour into pink when a base is added to the medium.

The titration process is held as below:

1. to the solution which will be tested, some amount of indicator is dropped.
2. Using the burette, drops of strong acid/base with known molarity in the burette is continiously added to the solution which will be tested drop by drop. Note that there are mL indicating numbers on the burette. Before starting the addition process, one should be aware of the level where the strong acid/base stands in the burette, so that in the end calculations can be made. (to have detailed information on level reading, refer to the section 'Level Reading on Burette').
3. While this adding process takes place, the beaker in which the solution is in is steadily shaked/vibrated/titrated so that the strong acid/base molecules may better diffuse in the solution. This is the reason why the process is called as titration.
4. At some point one will observe change in colour due to the indicator. At this point strong acid/base addition from the burette is stopped but the titration of the beaker is continued. When the change is colour is does not disappear for about 10 seconds or more, strong acid/base addition is completely stopped and the below calculations are made. The change in the colour of the solution indicates that the solution being tested had just been neutralised and is about to change its character from being acidic to being basic or from being basic to being acidic.
5. To be able to calculate the molarity of the tested solution, the volume of the strong acid/base in the burette, used in order to neutralise the tested solution should be known. As the burette is a pipe with numbers on it, indicating mL, the volume is found using these mL indicating values. The difference of the starting level -which is told in step 2- and the final level results is the volume of the strong acid/base in the burette.

Level Reading on Burette:



In the burette, most of the liquids stay in such position, especially the water. This is because the burette is very thin. In this position, it is easy to observe the adhesion and the cohesion forces.

The liquid level in the burette is not read from the upper limit, it is read from the lower limit.

Error Propogation:

1) Preparing 0.05 M NaOH

0.05 M NaOH * 500 mL = 2 M NaOH * x mL

From this equation, x is found to be 12.5 mL.

12.50 ± 0.10 mL , 2.00 ± 0.01 M NaOH , 500.00 ± 0.10 mL.

12.50 ± 0.10 mL has a percentage error of %0.8

2.00 ± 0.01 M has a percentage error of %0.5

500.00 ± 0.10 mL has a percentage error %0.5

Therefore, the percentage error of 0.05 M NaOH prepared is %18, which corresponds to 0.0500 ± 0.0090 M NaOH.

2) Preparing 0.01 M NaOH

0.01 M NaOH * 500 mL = 2 M NaOH * y mL

From this equation, y is found to be 2.5 mL

2.5 ± 0.10 mL, 2.00 ± 0.01 M, 500.00 ± 0.01 mL

2.5 ± 0.10 mL has a percentage error of % 4.

2.00 ± 0.01 M has a percentage error of %0.5

500.00 ± 0.10 mL has a percentage error %0.5

Therefore, the percentage error of 0.01 M NaOH prepared is %5, which corresponds to 0.0100 ± 0.0005 M NaOH.

Calculations for pH:

All calculations are made with using a TI-84 plus.

1) Sage Tea

16.10 + 17.00 + 15.70 + 15.10 + 17.50 + 17.10 + 15.00 + 16.60 + 15.90 + 18.10 + 17.40 + 17.60 + 16.90 + 15.7 + 16.80 (each value with an error of ± 0.05)

= 248.50 ± 0.10 = Sum 1

$$Average\ Volume\ for\ neutralising\ sage = \frac{Sum\ 1}{15\ trials}$$

$$Average\ Volume\ for\ neutralising\ sage = \frac{248.50}{15} = 16.57$$

Average Volume For Neutralizing Sage = 16.57 ± 0.05

M_{base}*V_{base} =M_{acid}*V_{acid}

0.0100 ± 0.0005 M * 16.5700 ± 0.1000 mL = x M * 150.0000 ± 0.1000 mL

0.0100 ± 0.0005 M has a percentage error of %5.
16.5700 ± 0.1000 mL has a percentage error of % 0.6035.
150.0000 ± 0.1000 mL has a percentage error of % 0.0667.

$$x\ M = \frac{0.01\ M * 16.57\ mL}{150\ mL} = 0.0011 = 11 * 10^{-4}$$

11.10^{-4} has a percentage error of % 5.6702

X M = 11.10^{-4} ± $0.6168.10^{-4}$

$$pH = -\log[H^{+}]$$

$$pH = -\log x$$

$$pH = -\log(11 * 10^{-4})$$

pH = 2.96 ± 0.01

2) Green tea with lemon

11.10 + 10.60 + 12.90 + 9.80 + 10.90 + 11.80 + 10.50 + 11.90 + 12.00 + 9.90 + 10.30 + 11.90 + 11.70 + 10.80 + 11.30

= 167.40 ± 0.10 = Sum 2

$$Average\ Volume\ for\ neutralising\ green\ tea = \frac{Sum\ 2}{15\ trials}$$

$$Average\ Volume\ for\ neutralising\ green\ tea = \frac{167.40}{15} = 11.2$$

$M_{base}*V_{base} = M_{acid}*V_{acid}$

0.0500 ± 0.0090 M * 11.2000 ± 0.1000 mL = x M * 150.0000 ± 0.1000 mL
0.0500 ± 0.0090 M has a percentage error of %18.
11.2000 ± 0.1000 mL has a percentage error of % 0.8928
150.0000 ± 0.1000 mL has a percentage error of & 0.0667.

$$x\ M = \frac{0.05\ M * 11.2\ mL}{150\ mL} = 0.003733 = 37 * 10^{-4}$$

$37.\ 10^{-4}$ has a percentage error of % 18.9595

X M = $37.\ 10^{-4} \pm 0.0010.\ 10^{-4}$

$$pH = -\log[H^{+}]$$

$$pH = -\log x$$

$$pH = -\log(37 * 10^{-4})$$

pH = 2.43 ± 0.01

3) Rosehip Fruit Tea

23.20 + 22.00 + 24.30 + 21.90 + 23.20 + 23.20 + 22.80 + 25.20 + 26.30 + 25.40 + 23.60 + 23.20 + 24.20 + 21.90 + 23.50

= 353.90 ± 0.10 = Sum 3

$$Average\ Volume\ for\ neutralising\ rosehip = \frac{Sum\ 3}{15\ trials}$$

$$Average\ Volume\ for\ neutralising\ rosehip = \frac{353.90}{15} = 23.59$$

M_{base}*V_{base} =M_{acid}*V_{acid}

0.0500 ± 0.0090 M * 23.5900 ± 0.1000 mL = x M * 150.0000 ± 0.1000 mL
0.0500 ± 0.0090 M has a percentage error of %18.
23.5900 ± 0.1000 mL has a percentage error of % 0.4329.
150.0000 ± 0.1000 mL has a percentage error of & 0.0667.

$$x\ M = \frac{0.05\ M * 23.59\ mL}{150\ mL} = 0.0079 = 79 * 10^{-4}$$

79.10^{-4} has a percentage error of % 18.4996.

X M = $79.\ 10^{-4}$ ± 14.10^{-4}

$$pH = -\log[H^+]$$

$$pH = -\log x$$

$$pH = -\log(79 * 10^{-4})$$

pH = 2.10 ± 0.01

4) Linden Herbal Tea

10.00 + 8.20 + 9.70 + 13.00 + 9.90 + 10.80 + 11.60 + 9.90 + 12.10 + 8.90 + 12.00 + 11.30 + 9.90 + 10.00 + 12.30

= 159.60 ± 0.10 = Sum 4

$$Average\ Volume\ for\ neutralising\ linden = \frac{Sum\ 4}{15\ trials}$$

$$Average\ Volume\ for\ neutralising\ linden = \frac{159.60}{15} = 10.64$$

M_{base}*V_{base} =M_{acid}*V_{acid}

0.0100 ± 0.0005 M * 10.6400 ± 0.1000 mL = x M * 150.0000 ± 0.1000 mL

0.0100 ± 0.0005 M has a percentage error of %5.
10.6400 ± 0.1000 mL has a percentage error of % 0.9398
150.0000 ± 0.1000 mL has a percentage error of % 0.0667.

$$x\ M = \frac{0.01\ M * 10.64\ mL}{150\ mL} = 7.1 * 10^{-4}$$

7.1 . 10^{-4} has a percentage error of & 6.0065

X M = 7.1 . 10^{-4} ± 0.4264. 10^{-4}

$$pH = -\log[H^{+}]$$

$$pH = -\log x$$

$$pH = -\log(7.1 * 10^{-4})$$

pH = 3.14 ± 0.01

Pictures:

Picture 1: one unit package of Sage Herbal Tea

Picture 2: one unit package of Green Tea with Lemon

Picture 3: one uint package of Rosehip Fruit Tea

Picture 4: one unit package of Linden Herbal Tea

Picture 5 (above): My apparatus I used for my trials. At the left front, you see the 4 250 mL beakers. In the middle, there is 2 M NaOH. At the left of the 2 M NaOH, there are the burettes.

Picture 6: the kettle I used in my trials.

Brand: Severin, 2200 watt

Picture 7: the brands of the teas I chose to experiment with (from top to down:)

1)“Doğadan” Sage Herbal Tea

2)“Doğuş Çay” Green Tea with Lemon

3)“Doğadan” Linden Herbal Tea

4)“Doğadan” Rosehip Fruit Tea

Picture 8 (above) : the colours of the tea solutions before they were titrated. From left to right, you see Sage Tea, Green Tea with Lemon, Rosehip Fruit Tea and Linden Herbal Tea. Sage Tea is light brown, Green Tea is yellow, Rosehip Tea is dark red and Linden Tea is very light yellow.

Picture 9 (above): The colours of the tea solutions after they are being itrated. From left to right, you see Sage Tea, Green Tea with Lemon, Rosehip Tea and Linden Tea. After the titration, Sage Tea becomes dark brown, Green Tea becomes reddish-brown, Rosehip Tea becomes nearly black and Linden Tea becomes pink.

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