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# Extraction of Soluble Components from Coffee Powder Using Different Solvents

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***Abstract***— *Coffee contains a lot of natural soluble components that can be extracted, like caffeine, chlorogenic acid and proteins. This experiment shows information about extracting soluble components from the two different brands of coffee powders using different solvents. The aims of this experiment are to discover the effect of several solvents (hot water, water and acetone) and the effect of different temperatures of water (25 °C,60 °C and 90 °C) on the extraction of soluble components from both coffee powders. As a result, it was found that the percentage of solvent soluble solids compounds was high in hot water, then normal water and it was very less in acetone. As for the effect of temperature and among all the temperatures, the % solvent soluble solids compounds were high at 90 °C and less at 25 °C. As a conclusion, it was identified that water is a very good solvent, it can dissolve many substances that some other solvents cannot dissolve (like acetone). In addition, it was found that at the higher the temperature of water, the greater its ability to dissolve more soluble components from coffee powder. Also, the solubility depends greatly on the quality of the coffee powder used, whether the granules are fine or coarse, small or big and contain other additives or not.*

***Keywords***— *Acetone, Coffee, Solvents, filtration, gnter key words or phrases in alphabetical order, separated by colon.*

## I. INTRODUCTION

Coffee is very popular brewed drink, which is prepared from roasted coffee beans. The coffee beans come from the coffee tree, which has a lot of green beans that turn into bright red beans when ripe. They go through many stages to produce the drink known as coffee (1). It has a dark color, strong taste (bitter), contains a little bit of acidity and it gives people a feeling of stimulation because of the presence of caffeine in. Moreover, coffee considered one of the most famous drinks in the world and each place in the world prepares it differently (1). The kinetics of trigonelline and coffee using espresso coffee made in a coffee machine under actual process settings, as well as coffee powder with various tamping pressures and particle sizes. It was discovered that the size of partials has a significant impact on extraction kinetics, with smaller molecules yielding more caffeine and trigonelline extraction. It was also shown that tamping pressure had no effect on the extraction kinetics. Furthermore, it was discovered that there is a factor influencing the coffee's composition, which is the total mass of coffee removed (2). Caffeine solubility was measured in $CCl_4$, $C_4H_8O_2$, $C_2H_5OH$, $CH_3OH$, $H_2O$, $CHCl_3$, $C_3H_6O$, and $CH_2Cl_2$ in this experiment using a gravimetrical method from (298 to 323) K, and the data was connected to temperature. Caffeine solubility decreased in the following order: $CHCl_3$, $CH_2Cl_2$, $C_3H_6O$, $C_4H_8O_2$, $H_2O$, $CH_3OH$, $C_2H_5OH$, and $CCl_4$. The value of caffeine solubility in CHCl3 was found to be higher than the values of the other solvents. As a result, CHCl3 is thought to be an useful solvent for separating and purifying caffeine from mixtures. As a result, it was discovered that when $C_2H_5OH$ was added as a common solvent to $H_2O$, caffeine solubility dropped, however when $C_4H_8O_2$ was added as a common solvent, caffeine solubility increased (3). NADES is a new solvent for extracting metabolites from plants that offers a number of environmental advantages, including biodegradability, cheap cost, low toxicity, the ability to dissolve both polar and non-polar molecules, and ease of production. The goal of this experiment was to use deep natural ultrasonography to see how extraction affects the enrichment of chlorogenic acid and caffeine in green coffee beans. The NADESUAE method of extracting caffeine and chlorogenic acid was employed in this work in a variety of extraction conditions, including NADES composition, water addition in NADES, and extraction time. The content of chlorogenic acid and caffeine was investigated. Caffeine (7.89 mg/g) and chlorogenic acid (28.62 mg/g) were found to be the highest in this study. In conclusion, this study found that the composition of NADES, extraction duration, and water addition are all critical elements in extracting chlorogenic acid and caffeine content from green coffee beans (4). Using pure supercritical carbon dioxide and supercritical carbon dioxide modified with $C_2H_5OH$ and $C_3H_8O$ as solvents, this study extracts caffeine, chlorogenic acid, and coffee oil from green coffee beans at fifty and sixty degrees and specified pressure (in Map). Samples for each solvent and combined solvent were collected in this study across various time intervals. When pure carbon dioxide and $CO_2$-ethanol mixed solvent were utilized, it was discovered that an increase in pressure occurred, which led to an increase in the amount of extracted oil. It was also discovered that when $CO_2$ was changed with isopropyl alcohol, the amount of extracted oil increased. Caffeine extraction increased at initially, then decreased as pressure increased. When $C_3H_8O$ was utilized as a common solvent, $C_{16}H_{18}O_9$ was extracted. The extraction of oil and caffeine reduced when only carbon dioxide was used as a solvent and the temperature was elevated (5). SCG is a natural source of antioxidants that can be used to recover phenolic components through an extraction procedure. They employ aqueous ethanol (30% v/v) as a solvent in a variety of situations, including extraction time, temperature, and

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liquid/solid ratio. They analyze the quantities of phenolic compounds using the Folin-Ciocalteu method. They expressed the figures in terms of gallic acid equivalent weight. They discovered that at a temperature of 60 °C, a liquid/solid ratio of 50 mL/g, and an extraction duration of 150 minutes, the maximum extraction yield was 87.3 percent. They discovered that the liquid/solid ratio and temperature are more essential than the extraction time (6). In this study the effect of solvents (hot water, water and acetone) on the extraction of soluble component in coffee powder and also the effect of temperature on the extraction of soluble components in coffee powder was carried out.

## II. METHODOLOGY

Brand A coffee powder which is a soluble, which can dissolve easily in the water (especially hot water). It is a combination of Arabica (15%) and Robusta (85%) coffee beans and Brand B coffee power is rich in aroma and taste coffee. It consists of 70% coffee and 30% chicory. It is a combination of both Arabica and Robusta beans was used in this experimental study. To study the effect of solvents one gram of powder of coffee (Brand A & B) powder was added in different conical flasks and then add 25 ml of hot water, water and acetone in each conical flask and then mix thoroughly. Then heat the mixture at $60^0$C in water bath for 20 minutes and allow it to cool for room temperature. The sample was filtered by using Whatman filter paper and the residue was placed in the oven for drying at 40 $^0$C. % Solvent Insoluble Solids Compounds and % Solvent Soluble Solid Compounds was calculated by measuring the mass of residue in water, hot water and acetone. The effect of temperature on solvents are studied for 25 $^0$C, 60 $^0$ C and 90 $^0$ C to study the % Solvent Insoluble Solids Compounds and % Solvent Soluble Solid Compounds was calculated.

## III. DISCUSSION

### A. *Effect of Solvent on coffee powder brand A*

It was found different amounts of insoluble solid compounds of brand A coffee powder for each solvent (Table 1). We found different amounts of insoluble solid compounds of coffee powder for each solvent for brand A is shown in Figure 1. Acetone has very high amount of insoluble solid compounds which is about 91%, due to the ability of acetone to deposition of proteins, as coffee contain proteins so it will not dissolve totally on acetone. Also, acetone is organic solvent and it is intermediate polarity as it contains has a polar carbonyl group and two non-polar methyl groups, so the solubility of coffee will be less in it due to the difference in the chemical properties of them. (7). On the other hot water has less amount of insoluble solids which is about 46.86%, and hot water have very less insoluble solid compound which is equal to 9.25%, conversely that means they have more soluble compounds, because water is polar solvent and chlorogenic acid is highly polar but caffeine is weakly polar compound, so coffee will dissolve easily in water especially hot water (8). As it is known that " like dissolves like " which means that when solute and solvent have the same chemical structure the solubility will be more (8).

TABLE I. Effect of solvent on coffee powder brand A

| Solvents | % SISC | % SSSC |
|---|---|---|
| Hot water | 9.25% | 90.75% |
| Water | 46.86% | 53.14% |
| Acetone | 91% | 9% |

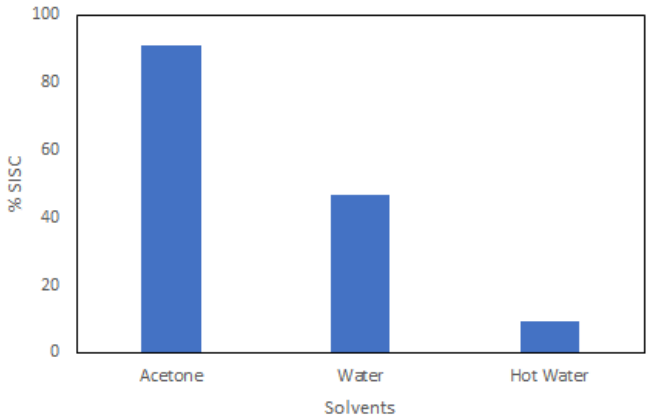


Fig. 1. Effect of Solvent on % Solvent in Soluble Solids Compounds on coffee powder brand A

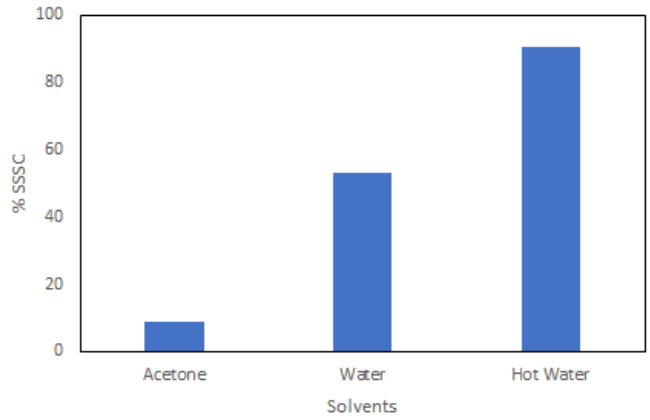


Fig. 2. Effect of Solvent on % Solvent Soluble Solids Compounds on coffee powder brand A

The solubility of brand A coffee powder in hot water (Table 1 and Figure 2) is very high when compared to water and acetone. The soluble compounds are very less in acetone which is equal to 9%, because acetone precipitates proteins of coffee (7). The solubility of Nescafé coffee powder in hot water is very high when compared to water and acetone. The soluble compounds are very less in acetone which is equal to 9%, because acetone precipitates proteins of coffee (7). Also, acetone is organic solvent and it is intermediate polarity as it contains has a polar carbonyl group and two non-polar methyl groups, so the solubility of coffee will be will be less in it due to the difference in the chemical properties of them (8).

There are 90.75% of soluble compound in hot water, and for water the soluble solid compounds are 53.14%. Due to some similar chemical structure of coffee and water and as they are polar, the compounds which have high polarity like chlorogenic acid will dissolve more easily in polar water. The temperature of hot water increases the solubility of coffee. When temperature increase, the molecules of water vibrate

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very quickly and it will be having more ability to interact and break down the coffee particles (8).

### B. *Effect of Solvent on coffee powder brand B*

It was found that the percentage of insoluble solid compounds of brand B coffee powder (Figure 3) for each solvent as shown in Figure 3. Acetone has very high amount of insoluble solid compounds which is about 82.9%, due to the chemical nature of acetone and its ability to precipitate proteins (7). On the other hand, water has less insoluble solids which is about 20% and hot water have very less insoluble solid compounds which is equal to 11%, because water is a good solvent due to its nature and its polarity as it can easily form hydrogen bonds. As coffee has polar component so it will dissolve more in water (8). While, the soluble compounds are very less in acetone which is equal to 17.1%, because it is difficult for polar compounds to dissolve in intermediate polar solvent. Also, acetone utilize to deposition of proteins, so coffee will not dissolve totally in it (7).

TABLE 2. Effect of solvent on coffee powder brand B

| Solvents | % SISC | % SSSC |
|---|---|---|
| Hot water | 11% | 89% |
| Water | 20% | 80% |
| Acetone | 82.9% | 17.1% |

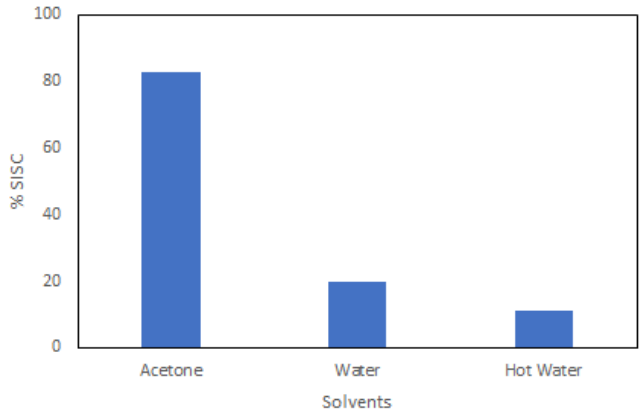


Fig. 3. Effect of Solvent on % Solvent In Soluble Solids Compounds on coffee powder brand B

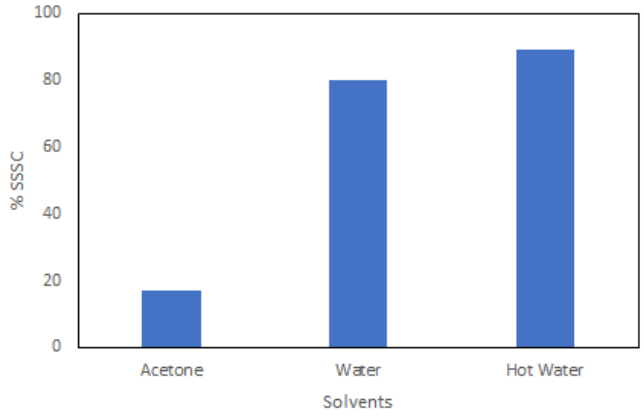


Fig. 4. Effect of Solvent on % Solvent Soluble Solids Compounds on coffee powder brand B

The solubility of brand B coffee powder in water and hot water is very high especially in hot water which is equal to 89% and for water it is equal to 80%, because the nature of coffee is polar due to its compounds which make it able to dissolve easily in water, as polar substance dissolve more in polar solvent. The temperature of hot water increase the solubility, as the temperature make water molecules move and vibrate very fast and help it to break the bonds easily as shown in Figure 4 (9).

### C. *Effect of Temperature on coffee powder brand A and brand B*

The percentage of insoluble solid compounds of brand A coffee powder for various temperature are studied as shown in the Table 3.

TABLE 3. Effect of temperature on coffee powder brand A

| Solvents/Temperature | Brand A | |
|---|---|---|
| | % SISC | % SSSC |
| Water ($25^0$C) | 15.61% | 84.39% |
| Hot water ($60\ ^0$C) | 12.66% | 87.34% |
| Hot water ($90\ ^0$C) | 11.07% | 88.93% |

This experiment was carried out to study the effect of temperature on coffee powder for brand A. The amount of insoluble solid compound in water at $25^0$C is high when compared to the other readings of hot water. At $25^0$C the percentage of SISC is 15.61%. While, the amount of insoluble solid compound decreased when we use water at $60^0$C, and it reach 12.66%. On the other hand, the hot water at $90^0$C extract the lowest amount of insoluble solid compounds which is about 11.07%. The % Solvent Insoluble Solids Compounds for water at $60^0$C and $90^0$C are little close to each other and the solubility decrease when temperature decrease for brand A coffee powder as shown in Figure 5(9).

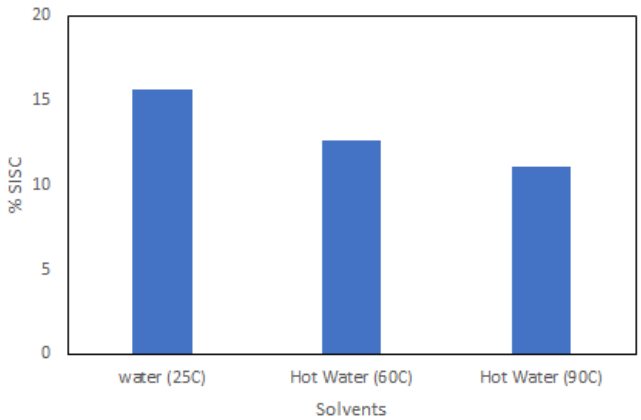


Fig. 5. Effect of temperature on % Solvent In Soluble Solids Compounds on coffee powder brand A

This was performed to find the different amount of soluble solid compounds produced for each temperature. While, the solubility increases when the temperature increases, where %SSSC. The % Solvent Soluble Solids Compounds for water at $60^0$C and $90^0$C are very close to each other. as the solubility increase when temperature increased, because high

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temperatures make water molecules move fast and help it to interact and break down the bonds easily as shown in Figure 6 (9).

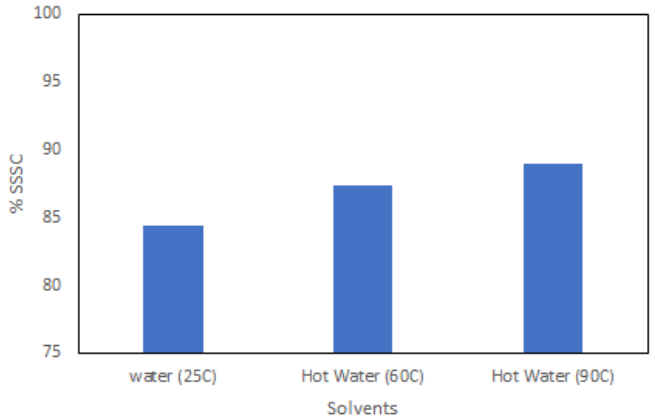


Fig. 6. Effect of temperature on % Solvent Soluble Solids Compounds on coffee powder brand A

TABLE 4. Effect of temperature on coffee powder brand B

| Solvents/Temperature | Brand A | |
|---|---|---|
| | % SISC | % SSSC |
| Water ($25^0$C) | 16.53% | 84.47% |
| Hot water ($60\ ^0$C) | 14.18% | 85.82% |
| Hot water ($90\ ^0$C) | 13.81% | 86.19% |

The percentage of insoluble solid compounds of brand B coffee powder for various temperature are studied as shown in the Table 4.

This experiment was carried out to study the effect of temperature on coffee powder for brand B. The amount of insoluble solid compound in water at $25^0$C is high when compared to the other readings of hot water. At $25^0$C the percentage of SISC is 16.53%. While, the amount of insoluble solid compound decreased when we use water at $60^0$C, and it reach 14.18%. On the other hand, the hot water at $90^0$C extract the lowest amount of insoluble solid compounds which is about 13.81%. The % Solvent Insoluble Solids Compounds for water at $60^0$C and $90^0$C are little close to each other and the solubility decrease when temperature decrease for brand A coffee powder as shown in Figure 7(9).

The solubility increases when the temperature increase to $60^0$C, where SSSC of it is equal to 85.82%. Moreover, hot water at $90^0$C extract 86.19% of soluble component. The % Solvent Soluble Solids Compounds for water at $25^0$C, $60^0$C and $90^0$C are close to each other. Hot water at $90^0$C is very efficient to extract more amount of soluble compounds for brand B coffee powder, as the solubility increase when temperature increased, because the movement of water molecules increase when temperature increased, which lead to finish the reaction quickly as it has the ability interact and break down the bonds between molecules (9). Where the solubility of brand B coffee powder in water at $25^0$C is less when compared to the other temperature, it reached to 83.47%, because chlorogenic acid is dissolve freely at $25^0$C as shown in Figure 8 (9).

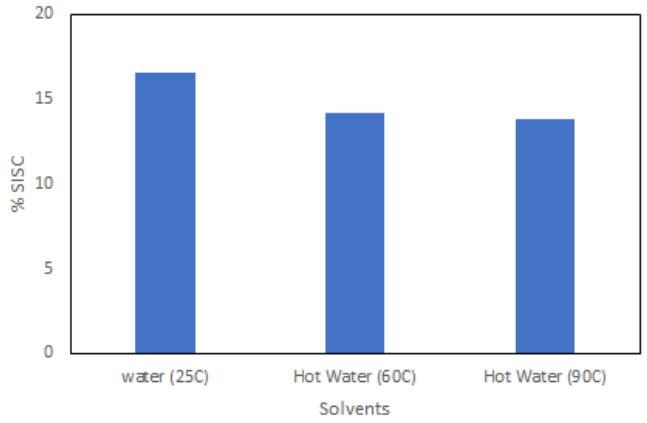


Fig. 7. Effect of temperature on % Solvent In Soluble Solids Compounds on coffee powder brand B

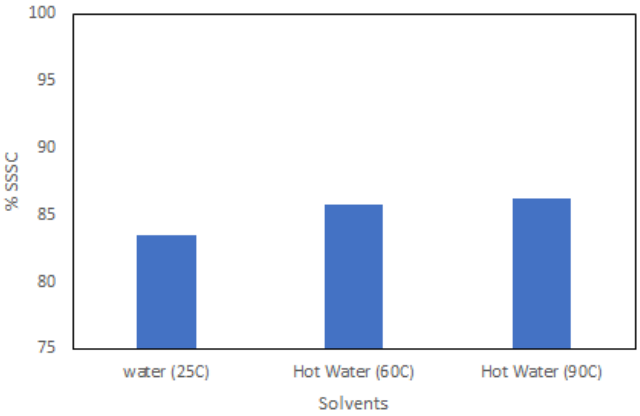


Fig. 8. Effect of temperature on % Solvent Soluble Solids Compounds on coffee powder brand B

## IV. CONCLUSION

The experiments were conducted to determine the factors affecting the solubility of coffee powder for brand A and B. The solubility of coffee powder in acetone was very less for both samples. This is due to the intermediate polarity of acetone and organic nature which utilize to deposition of proteins, as coffee contain protein so it will not dissolve totally on it (7). The hot water showed high results of the solubility of both types of coffee powder. The hot water is the best solvent to get high solubility, due to the polarity and nature of water, the polar compounds of coffee will dissolve easily in water. Also, It contains hydroxyl group which help it to increase the solubility, where coffee also have COOH and OH group (9). Moreover, temperature had a great effect on the solubility, so higher temperature yield greater solubility of coffee. The science of solids has large effect on solubility, as brand A coffee powder are in form of granules and brand B is in the form of fine powder. Also, there is an important role of extraction of dissolving components to the extraction of components of coffee powder from the surface and near the surface volume of solids for grind matrix, which mean that the mass transfer area for the granules is less when compared to data of fine powder, so it will not diffuses very fast because of bigger size. While, fine powder will diffuse very fast. As for less dissolving, mass transfer of the compound of it is less due

to intragranular pores into intergranular pores because it is in bulk form (9).

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