The influence of brewing water characteristic on sensory perception of pour-over local coffee

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Abstract. The coffee quality can be characterized by its multisensory perceptions. The content and mineral composition and other substances of brewing water can affect the result of brewed-coffee. The water may influence in extraction capabilities and flavor clarity. The ground Dampit coffee and two commercial instant coffee with pour-over method were used in this study. Various types of commercial drinking water were used to brew the coffee. The result suggests that the different brewing water affects the intensity of sweet and chocolate aroma, as well as oily mouth-feel. Surprisingly, taste and flavour attributes were not affected by the pH of brewing water within the range of 5.5 to 9.1.

Key words: Alkalinity, Water, Coffee, Sensory, Hardness

1. Introduction

Coffee (Coffea sp.) is widely cultivated plant in the world. According to [1], coffee contains nearly a thousand volatile compounds which are developed during roasting process. As it is very rich in flavours, coffee is considered as the most popular beverage in the world. Based on the International Coffee Organization (ICO), the world coffee consumption rate in 2015 reached 152.2 million per 60 kg of coffee sachet and increased 2.0% annual average since 2011 [2]. In Indonesia, the coffee consumption in the last 4 years continues to increase by 36% from 2010-2014 by the amount of 1.03 kg/capita/year by 2014 [3].

Basically, multisensory perception on coffee could be influenced by brewing method, temperature, roasting, coffee varieties, storage condition, grinding, and brewing water [4, 5, 6]. Based on its genetic, coffee is distinguished into Arabica coffee and robusta coffee which has its own characteristic and flavor. Robusta coffee contains more dissolved solids, therefore it is widely used in commercial instant coffee to add body to the solution and increase the extraction yield [7]. In addition, based on the process, the coffee can be classified as instant coffee and ground coffee. The process of making instant coffee involves the industrial process from roasting until drying extraction. Meanwhile, ground coffee involves a more traditional and simple process of grinding.

One of the coffee-brewing methods according to SCAA is pour over. The method is relatively well known, due to its simple way of brewing. The principle is to pour boiling water into a coffee powder to extract the powdered-coffee. Pour over coffee should be waited a while until the coffee grounds settle completely before it is consumed by consumers [8].

One of the factors that influence the perception of coffee multisensory is brewing water. The content and composition of minerals and other substances can affect the result of brewing coffee. This water
baking quality can be represented by total hardness and alkalinity. Total hardness is defined as the amount of calcium and magnesium in an equivalent concentration [9, 10, 11]. According to the Specialty Coffee Association of Europe (SCAE), the total limit of hardness content or CaCO$_3$ contained in the upper limit of hardness or CaCO$_3$ is 175 ppm whereas the lower limit is 50 ppm [12]. In sensory evaluation, consumers judge water quality by its clarity, palatability and odor. Thus, the threshold test is important to ensure the water is odorless as it is required for being palatable [13].

According to [14], there is a difference of binding extraction between Ca$^{2+}$, Mg$^{2+}$ and Na$^+$ cations with five acid components in coffee that is lactic acid, malic acid, citric acid, quinic acid, and chlorogenic acid, then in caffeine in the form of alkaloids, and coffee flavor characteristic on eugenol. Na$^+$ has the lowest binding when compared with the other two minerals. Na$^+$ does not facilitate the extraction between caffeine and eugenol, because the binding is not significant as the five acids present in coffee. Binding between the minerals with the highest coffee component is on Mg$^{2+}$. This mineral binds more of the desired flavor of coffee. In Ca$^{2+}$ the binding of mineral of the coffee component is not as high as the Mg$^{2+}$ [14].

As it has been reported that some minerals in water affect the extraction of particular components of coffee, it is hypothesized that different quality of water may affect the sensory attributes of extracted coffee. Therefore, in this current study, mainly two types of water; alkaline and oxygenated water were investigated. Both waters was expected to modify the brewed coffee characteristics as they may different in mineral content and pH. According to [15], one of the factors that can affects coffee extraction is mineral content. The higher mineral content in the water may lead to higher pH of water. In addition, [16] suggests that oxygenated water may affect extraction capabilities and flavor clarity of coffee.

Different type of brewing water allegedly could affect the coffee brewing result. This study aims to provide scientific report related to influence of different types of brewing water on sensory perception of particularly Indonesian coffee. This information may be very useful for barista all over the world to specify the required water quality for optimising the used brewing techniques.

2. Materials and Methods

2.1 Preparation of sample and coffee making

There were 2 groups of coffee used in this study; namely ground and instant coffee. The ground coffees were represented by ground Robusta coffee derived from mixture of all regions in Indonesia, including Dampit-Robusta coffee. Meanwhile, the instant coffee were represented by Robusta coffee derived from mixture of all regions in Indonesia and Arabica coffee from Mandailing area of Sumatra. Pour over method was chosen as the brewing technique in this study due to its simplicity and popularity among local coffee consumers.

There were 11 different types of water based on the differences of mineral and pH content that being used in this study. They were San Benedetto, Cleo, Aqua, Fitoxy, Oxygenizer, E$^+$, Total 8$^+$, Milagros, Super O2, tap water and refilled water.

Coffee making refers to the coffee-making standard for sensory analysis on ISO 6668:2008, as much as 7 grams of brewed coffee used in 100 ml of boiling water of 92°C-96°C with unfiltered pour over method. In this study, the coffee presented for sensory analysis was prepared by brewing 3.5 grams of coffee in 50 ml of water for 3 minutes. The coffee was served to the panels at 60±5°C for aroma evaluation first, followed by oral experience assessments.

2.2 Panellist’s recruitment

The panellists were recruited from Brawijaya University students, covering both genders equally from 20 to 23 years old. The criteria of candidates are those who have basic knowledge of sensory testing, have an interest for being trained panellist, have been accustomed to the attributes of a food product and
preferably have a habit to coffee consumption, having knowledge of coffee, being willing to consume coffee, having good healthy condition, having good communication skills, and able to provide a detailed description of product [17].

2.3 Panellist selection
This research uses the Quantitative Descriptive Analysis (QDA) method which is done by three stages; panellist selection, training and intensity assessment of coffee sensory attributes [18]. The candidates were required to pass two stages of selection; the aroma recognition test and basic recognition test. They needed to answer correctly at least 80% of overall aroma and basic taste in the test to get selected. Then after passing the selection, the panellists were tested their absolute threshold determine the threshold sensory capability of each panellist. The absolute threshold test was performed by 3-AFC (Alternative Forced Choice) method against five basic tastes of acid, sweet, bitter, salty, and umami [18].

| Attribute | Definition | Reference |
|-----------|------------|-----------|
| Aroma     |            |           |
| Sweet     | Sweet caramel-like | Toffleco caramel splint (2 drops) |
| Chocolate | Chocolate brewed-like | Van Houten brown powder (6% b/v) |
| Roasting  | Roasted coffee aroma | Roasted Dampit coffee beans (5-8 seeds) |
| Burnt     | Burnt cassava aroma | Burnt cassava (1 slice of ±5 cm diameter) |
| Acid      | Citrus acid aroma | Red bell tangerine (2 drops) |
| Taste     |            |           |
| Bitter    | Bitter taste | Pure caffeine P.A (0.03% b/v) |
| Vinegar acid | Vinegar-like taste | Dobbel vinegar (1% v/v) |
| Citric acid | Citric acid taste | Pure citric acid P.A (0.04% b/v) |
| Salty     | Salty | Refina kitchen salt (0.4% b/v) |
| Flavor    |            |           |
| Cassava   | Burnt Cassava Flavour | Burnt cassava (1 slice ±5 cm diameter) |
| After Taste |            |           |
| Astringent | Astringent | Cranberries HBF International (1 piece) |
| Sweet     | Sweet | Sugar (0.5% b/v) |
| Mouth-feel|            |           |
| Dry       | Dry sensation bean-like | Roasted ground beans (1 seed) |
| Oily      | Oily sensation | Butter Salt Anchor Fonterra (5 ml) |
2.4 Development of attribute vocabulary and panellist training

Vocabulary development was conducted through discussions of sensory attribute in two sessions to gain agreement of terminologies used in the test. The development of standard vocabulary was then followed by the agreement on definitions and references of each sensory attribute [17]. The selected panellists were then trained to assess the intensity of each attribute reference that has been previously agreed using line scale [18]. References training were conducted twice a week to see the panellist’s consistency on the intensity assessment of each reference [19]. The results of attribute agreed by panellists are shown in Table 1.

2.5 Descriptive analysis of sensory perceptions

Panels assessed the intensity of the sensory attributes of each sample of coffee using 15 cm unstructured line scales, anchored at 1 cm both ends. A total of 55 coffee samples were given to the panels by testing each sample of combination between each coffee and water and repeating one sample each type of coffee with each type of water randomly. Each sample was served at 60±5°C on a 120 ml paper cup containing 50 ml of coffee. Samples were presented randomly to the panellists.

2.6 Data analysis

The descriptive test data of coffee were analyzed using Analysis of Variance (ANOVA) with Generalized Linear Model (GLM) on Minitab 17, followed by Tukey test. Multivariate data analysis was also conducted by Principal Component Analysis (PCA) on Minitab 17.

2.7 Chemical and physical analysis

2.7.1 Mineral content testing with AAS (Atomic Absorption Spectroscopy). In this study, the mineral content test was done by using Atomic Absorption Spectroscopy (AAS). This test is a quantitative method of elemental analysis based on the absorption of light of a certain wavelength by metal atom in a free state [20]. If light of a certain wavelength is passed to a cell containing free atoms the some of the light will be absorbed and the absorption intensity will be proportional to the number of free metal atoms in the cell [21].

2.7.2 pH analysis. pH measurements in this study were conducted after coffee descriptive test. Coffee pH measurements were performed for each samples before and after the consuming (spit out). The pH measurements of spit out samples were done shortly after the panels consumed the coffee to avoid the pH changes during storage. pH measurement was performed using pH meter that had been calibrated using standard solution of pH 4 and 7 at room temperature. The pH meter was calibrated before taking pH measurements of the sample and calibration was done for each measurement of five samples. Each samples was measured pH twice.

3. Result and Discussion

3.1 Mineral Content of Each Water Type Based on Atomic Absorption Spectroscopy (AAS)

Each type of water tends to have different mineral content (Table 2). Water code 5 has the highest mineral content of Ca 6,845 mg/L, Mg 1.178 mg/L and Na 167.550 mg/L. While water code 11 has the lowest detectable mineral content of Na 0.97 mg/L. Mineral content of Ca and Mg of some types of water were not detected as they were below the detection limit.

The different mineral content in brewing water affects the pH of ground coffee type. Water which are containing lower Ca, Mg, and Na tend to induce lower pH of brewed ground coffee, compared to those of higher mineral content (Table 3). Similarly, the pH of the ground coffee after consumed, although the pH
increased to be higher, the brewed ground coffee that brewed with the low mineral content has a lower pH than that of other ground coffee. However, the mineral content of brewed water has slightly changed the pH on instant coffee before the consumption or after consumption. As pH of instant coffees slightly increased after consumption (Table 3), it suggest that interaction of saliva and coffee components may involve in perceiving coffee.

Table 2. Atomic Absorption Spectroscopy Result

| Water type | Ca (mg/L) | Mg (mg/L) | Na (mg/L) | CaCO₃ (mg/L) |
|------------|-----------|-----------|-----------|--------------|
| 1          | 6.713     | 1.177     | 26.440    | 21.607       |
| 2          | 6.349     | 1.019     | 67.550    | 20.052       |
| 3          | 0.031     | -         | 12.050    | -            |
| 4          | 6.459     | 1.012     | 60.190    | 20.298       |
| 5          | 6.845     | 1.178     | 167.550   | 21.945       |
| 6          | 0.317     | 1.086     | 10.85     | 5.264        |
| 7          | 5.686     | 0.952     | 46.48     | 18.118       |
| 8          | -         | 0.912     | 5.32      | 3.759        |
| 9          | 1.183     | 0.286     | 2.31      | 4.133        |
| 10         | 0.121     | -         | 0.41      | 0.302        |
| 11         | -         | -         | 0.97      | -            |

Description of water code:
- 1: mineral water brand A
- 2: mineral water brand B
- 3: mineral water brand C
- 4: mineral water refill
- 5: tap water
- 6: alkaline water brand A
- 7: alkaline water brand B
- 8: alkaline water brand C
- 9: oxygenated water brand A
- 10: oxygenated water brand B
- 11: oxygenated water brand C

Low mineral content in drinking water can affect the pH. Low mineral content tends to have a low pH as well. Water with codes 3, 9, 10, and 11 have a low Ca, Mg, and Na minerals and have a pH range of 5.8-6.85. Low mineral content also affects the stability test results, water codes 9, 10, and 11 tend not to have stable pH. The pH of water after consumption or with saliva tends to increase toward neutral in the pH range of 6.3 to 7.

Differences in pH and mineral content of water samples varied considerably shown on Table 4. Nevertheless, the difference in water samples has only significant effect on the attributes of sweet aroma, chocolate aroma, and oily mouth-feel. The vinegar taste and citric acid taste is not affected by water differences. This is reinforced by the result of coffee pH test brewed with various types of water tend to be in the pH range 4.9-6.1. Ground type of coffee (A and B) has a pH range of 5.5-6.1 and instant coffee (C and D) has a lower pH range and a closer range of 4.9-5.1
3.2 pH Test of Coffee

**Table 3.** before and after pH on coffee consumption

| Coffee | Water |   |   |   |   |   |   |   |   |   |
|--------|-------|---|---|---|---|---|---|---|---|---|
|        | 1     | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10|
| **Before Consumption** |       |   |   |   |   |   |   |   |   |   |
| A      | 5.8   | 5.9| 5.7| 5.9| 6.1| 5.7| 5.7| 5.6| 5.7| 5.6|
| B      | 5.8   | 5.9| 5.7| 5.9| 6.1| 5.9| 5.85| 5.55| 5.6| 5.55|
| C      | 4.9   | 5  | 4.9| 5  | 5  | 5  | 5.1 | 5   | 4.95 | 5 | 4.8|
| D      | 4.9   | 4.9| 4.8| 4.9| 4.9| 4.9| 4.9 | 4.8 | 4.9 | 4.8|
| **After Consumption** |   |   |   |   |   |   |   |   |   |   |
| A      | 6.3   | 6.2| 5.9| 6.2| 6.3| 6.1| 6.1| 5.7 | 5.7 | 5.7 | 5.7|
| B      | 6.2   | 6  | 5.8| 6.2| 6.2| 5.9| 6.1| 5.8 | 5.8 | 5.85| 5.87|
| C      | 5.1   | 5.1| 5.1| 5.1| 5.1| 5.1| 5.1 | 5.1 | 5   | 5  | 5  |
| D      | 5.5   | 5  | 5  | 5  | 5  | 5  | 5.1 | 4.9 | 4.9 | 4.9 | 4.9|
| Pure Water | 7.6 | 6.7| 5.8| 7  | 6.8| 8.25| 8.2 | 8.05| 6.7 | 6.85| 6.5|

Description of water code:
1 : mineral water brand A  
2 : mineral water brand B  
3 : mineral water brand C  
4 : mineral water refill  
5 : tap water  
6 : alkaline water brand A  
7 : alkaline water brand B  
8 : alkaline water brand C  
9 : oxygenated water brand A  
10 : oxygenated water brand B  
11 : oxygenated water brand C

3.3 *Descriptive analysis test based on coffee differences*

The data ([Table 4](#)) showed that the difference of coffee type had a significant effect on the attributes of sweet aroma, chocolate aroma, roasting aroma, burnt aroma, citrus aroma, bitter taste, vinegar taste, salty taste, cassava flavor, astringency aftertaste, dry mouth-feel and oily mouth-feel. However, there is no significant effect on the sweet after taste attribute.
Table 4. Result table of attribute sensory

| Attribute    | A       | B       | C       | D       | Ground  | Instant | Robusta | Arabica |
|--------------|---------|---------|---------|---------|---------|---------|---------|---------|
| **Aroma**    |         |         |         |         |         |         |         |         |
| Sweet        | 3.868<sup>b</sup> | 3.189<sup>c</sup> | 3.830<sup>b</sup> | 4.886<sup>a</sup> | 3.507<sup>b</sup> | 4.354<sup>a</sup> | 3.619<sup>b</sup> | 4.852<sup>a</sup> |
| Chocolate    | 2.976<sup>a</sup> | 2.784<sup>ab</sup> | 2.365<sup>bc</sup> | 2.050<sup>c</sup> | 2.848<sup>a</sup> | 2.214<sup>b</sup> | 2.706<sup>a</sup> | 2.014<sup>b</sup> |
| Roasting     | 5.381<sup>a</sup> | 5.748<sup>a</sup> | 4.502<sup>b</sup> | 3.047<sup>c</sup> | 5.548<sup>a</sup> | 3.767<sup>b</sup> | 5.209<sup>a</sup> | 3.030<sup>b</sup> |
| Burnt        | 2.260<sup>a</sup> | 1.954<sup>ab</sup> | 1.539<sup>b</sup> | 1.560<sup>b</sup> | 2.104<sup>a</sup> | 1.546<sup>b</sup> | 1.922<sup>b</sup> | 1.537<sup>b</sup> |
| Citrus       | 0.329<sup>c</sup> | 0.489<sup>c</sup> | 1.486<sup>b</sup> | 2.799<sup>a</sup> | 0.410<sup>b</sup> | 2.160<sup>a</sup> | 0.771<sup>b</sup> | 2.803<sup>a</sup> |
| **Taste**    |         |         |         |         |         |         |         |         |
| Bitter       | 5.683<sup>a</sup> | 4.197<sup>b</sup> | 4.903<sup>ab</sup> | 4.863<sup>b</sup> | 4.921<sup>a</sup> | 4.908<sup>a</sup> | 4.926<sup>b</sup> | 4.882<sup>a</sup> |
| Vinegar acid | 1.078<sup>c</sup> | 0.607<sup>c</sup> | 3.337<sup>5</sup><sup>b</sup> | 4.590<sup>a</sup> | 0.836<sup>b</sup> | 3.966<sup>a</sup> | 1.664<sup>b</sup> | 4.581<sup>a</sup> |
| Citric acid  | 1.080<sup>c</sup> | 0.664<sup>c</sup> | 3.583<sup>b</sup> | 4.232<sup>a</sup> | 0.868<sup>b</sup> | 3.867<sup>a</sup> | 1.770<sup>b</sup> | 4.142<sup>a</sup> |
| Salty        | 0.489<sup>c</sup> | 0.399<sup>c</sup> | 1.915<sup>b</sup> | 3.170<sup>a</sup> | 0.439<sup>b</sup> | 2.542<sup>a</sup> | 0.937<sup>b</sup> | 3.125<sup>a</sup> |
| **Flavor**   |         |         |         |         |         |         |         |         |
| Cassava      | 3.426<sup>a</sup> | 2.370<sup>b</sup> | 1.943<sup>bc</sup> | 1.749<sup>c</sup> | 2.890<sup>b</sup> | 1.851<sup>b</sup> | 2.585<sup>a</sup> | 1.734<sup>b</sup> |
| **After taste** |         |         |         |         |         |         |         |         |
| Astringent   | 2.214<sup>b</sup> | 1.638<sup>a</sup> | 4.014<sup>a</sup> | 3.578<sup>a</sup> | 1.923<sup>b</sup> | 3.783<sup>a</sup> | 2.628<sup>b</sup> | 3.525<sup>a</sup> |
| Sweet        | 0.653<sup>a</sup> | 0.756<sup>a</sup> | 0.663<sup>a</sup> | 0.757<sup>a</sup> | 0.703<sup>b</sup> | 0.713<sup>a</sup> | 0.692<sup>a</sup> | 0.755<sup>a</sup> |
| **Mouthfeel**|         |         |         |         |         |         |         |         |
| Dry          | 3.345<sup>b</sup> | 2.146<sup>c</sup> | 3.615<sup>a</sup> | 2.772<sup>c</sup> | 2.718<sup>b</sup> | 3.218<sup>a</sup> | 3.033<sup>a</sup> | 2.779<sup>a</sup> |
| Oily         | 2.165<sup>b</sup> | 2.300<sup>b</sup> | 2.463<sup>ab</sup> | 2.813<sup>a</sup> | 2.222<sup>b</sup> | 2.618<sup>a</sup> | 2.312<sup>b</sup> | 2.737<sup>a</sup> |

Description of water code:
1: ground coffee brand A
2: ground local coffee B
3: instant coffee brand A
4: instant coffee brand B

3.4 Descriptive analysis test based on water differences
The different types of water tend to have significant effect on average attribute intensity (p-value<0.05).
The attributes of sweet intensity in water code 3, while water code 1 has a high intensity on chocolate aroma and oily mouth-feel.
Table 5. Coffee sensory attributes as affected by 11 different water

| Attribute   | 1     | 2     | 3     | 4     | 5     | 6     | 7     | 8     | 9     | 10    | 11    |
|-------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| Aroma       |       |       |       |       |       |       |       |       |       |       |       |
| Sweet       | 4.377bc| 4.380bc| 4.648g| 4.567ab| 3.944bcd| 3.539bcd| 3.740bcd| 3.216cd|       |       |       |
| Chocolate   | 3.478y | 3.347y | 3.056xy| 3.044xy| 1.953xy| 1.795xy| 2.019yd| 1.986yd| 2.136yb| 1.912y|       |
| Roasting    | 4.914f | 5.170f | 4.968f | 4.992f | 5.060f | 4.654f | 4.444f | 4.452f | 4.105f | 4.448f| 4.116f|
| Burnt       | 2.103d | 2.228d | 1.887d | 2.215d | 2.158d | 2.158d | 2.160d | 2.165d | 2.168d | 2.169d| 2.170d|
| Citrus      | 1.356f | 1.127f | 1.132f | 1.230f | 1.380f | 1.414f | 1.294f | 1.486f | 1.228f | 1.033f| 1.355f|
| Taste       |       |       |       |       |       |       |       |       |       |       |       |
| Bitter      | 4.770f | 4.889f | 4.898f | 4.844f | 5.227f | 5.111f | 4.605f | 4.738f | 4.856f | 4.851f|       |
| Vinegar     | 2.541d | 2.503d | 2.679d | 2.872d | 2.439d | 2.090d | 1.994d | 2.365d | 2.465d | 2.437d| 3.047d|
| Citric Acid | 2.480f | 2.278f | 2.617f | 2.424f | 2.491f | 2.215f | 1.793f | 2.524f | 2.643f | 2.349f| 2.471f|
| Salty       | 1.628f | 1.477f | 1.733f | 1.728f | 1.553f | 1.528f | 1.050f | 1.490f | 1.320f | 1.361f| 1.553f|
| Flavor      |       |       |       |       |       |       |       |       |       |       |       |
| Cassava     | 2.405f | 2.238f | 2.268f | 2.302f | 2.629f | 2.495f | 2.512f | 2.359f | 2.286f | 2.561f| 2.033f|
| Astringent  | 3.282f | 3.339f | 3.138f | 3.219f | 3.305f | 2.464f | 2.579f | 2.659f | 2.481f | 2.560f| 2.696f|
| Sweet       | 0.734d | 0.603d | 0.764d | 0.896d | 0.857d | 0.706d | 0.526d | 0.712d | 0.636d | 0.537d| 0.810d|
| Mouthfeel   |       |       |       |       |       |       |       |       |       |       |       |
| Dry         | 3.410f | 3.133f | 3.015f | 2.940f | 3.200f | 2.984f | 2.763f | 2.627f | 2.568f | 2.855f| 3.167f|
| Oily        | 2.844f | 2.646f | 2.390f | 2.696f | 2.824f | 2.378f | 1.886f | 2.318f | 2.297f | 2.288f| 2.221f|

3.5 Principal Component Analysis

The first two principal components (PCs) explained 80.2% of variation in the data set for 24 data variation. Sample were separated across PC1 (68%) according to samples that were scored highly for vinegar taste, citric acid taste, and salty taste. PC 2 (12.2%) separated samples with high scored in bitter taste, dry mouthfeel, and chocolate aroma.

According to Figure 1, there are some strong positive correlation between attributes citric acid and vinegar taste, between dry mouthfeel and bitter taste, between salty taste and citric acid taste. There also a correlation between burnt aroma and cassava flavor. The correlation between the attribute will be explained based on the table below the figure.
**Figure 1.** Principal Component Analysis

**Table 6.** Pearson Correlation and Paired T-test on PCA correlation

| Correlation                              | PCC, r² |
|------------------------------------------|---------|
| Citric acid and vinegar taste            | 0.931   |
| Dry mouth-feel and bitter taste          | 0.533   |
| Salty taste and citric acid taste        | 0.902   |
| Burnt aroma and cassava flavour          | 0.563   |

Based on the correlation coefficient table of pearson’s product moment, the critical value limit for 12 panels is 0.576 on the P-value <0.05. While the PCC score shows the consistency of individual assessment of each panels against the intensity of the attribute, the PCC value >0.576 means that the two attributes are not significantly different.

According to the **Table 6**, the correlation between citric acid and vinegar taste has PCC>0.576. Thus it indicates that both attributes were understood somehow as the same. Vinegar is a transformation of wine or fruit a chemical process in which ethyl alcohol converted to acetic acid. Thus the correlation is between the acid in those 2 attributes is remain strong. According to [22] on the pH range between 4.5-6.5 the taste perception of citric acid and vinegar taste tend to not have a significantly differences between those two
taste. In this study a correlation between the taste of vinegar and citric acid taste on coffee perception was observed within the range of pH 4.8 to 6.3.

The combination between salty taste and citric acid taste also does not show a significant difference, with the PCC>0.576. That is because the location of sub modalities sour and saltiness closed. The saltiness located on the tip of tongue while sour is on lateral aspects of the tongue. Because of this close proximity, causes the possibility of salty and acidic taste have the similar taste [23]. And according to [24] citric acid may increase the effect of salt taste perception on low levels of NaCl.

4. Conclusions

Within the range of 5.5 to 9.13, the pH of brewing water has no significant effect on taste and flavor of Indonesian brewed coffee. However, the different brewing water affects the aroma of coffee, especially sweet and chocolate aroma, as well as oily mouth-feel of pour-over Indonesian coffee.

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