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The potentials of Robusta (*Coffea Robusta* L.) and Arabica (*Coffea Arabica* L.) coffee leaf by-product as anti-diabetic drinks

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Abstract

It has been known that coffee leaf contain various bioactives and antioxidants. While diabetes can be indicated by the damage of pancreatic beta cells, numerous studies have reported that many kinds of antioxidants can recover the beta cells. As a result, coffee leaf tea has the potential to be developed as an anti-diabetic beverage. The current study used in vivo experiments to investigate the functionality of coffee leaf tea for diabetic therapy. Robusta and Arabica coffee leaf were processed as oolong tea. All samples were soft-infused. Healthy and diabetic rats (induced with streptozocin (STZ) intraperitonially at 80 mg/kg BW) were treated by injecting the softly infused coffee leaf tea 12 ml/kg BW/day for 28 days. Compared to the glibenclamide treatment, diabetic rats injected with Robusta coffee leaf tea were better at lowering blood sugar (p-value <0.05), as well as maintaning body weight. This is supported by the fact that the number of pancreatic beta cells in diabetic rats injected with Robusta coffee leaf tea was significantly higher than in glibenclamide treated rats (p-value <0.05). Coffee leaf tea tend to have a lighter sensory profile than oolong tea. It can be concluded that Robusta coffee leaf tea tends to be potentially developed as anti-diabetic drink since it can recover damaged pancreatic beta cells better than glibenclamide, thus helping to decrease blood sugar.

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1. Introduction

Coffee leaf tea, also called locally as "Kawa Daun", is one of the herbal teas popular in Indonesia, particularly in West Sumatra. Coffee leaf, as by-product from the pruning process, has the potential to be used as an ingredient for coffee leaf tea, or *kawa daun* (1). From trimming 1 hectare of land, or about 2000 coffee plants, it is predicted that young coffee leaf may be harvested for about 14 tons, and that which has the potential to be used as raw material for coffee leaf tea can reach 700 kg (2).

Coffee leaf tea is made from old coffee leaf from the pruning of coffee trees and the drying process. The dried coffee leaf then boiled until they produce a brownish drink, like the result of steeping tea leaf (3). As reported by Chen et al. (4), coffee leaf tea contains numerous bioactives such as phenolic compounds, tannin, and flavonoids. The sensory characteristics of Robusta coffee leaf tea were strongly affected by the age of the leaf. The total phenolic compound (TPC) value of old coffee leaf was higher than that of young coffee leaf (5). Phenolic compounds are responsible for bitterness and astringency (6,7). Coffee leaf with high antioxidant content has high quality and the potential to be accepted by consumers (8). Moreover, TPC can also act as an antidiabetic agent by inhibiting alpha glucosidase activity

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which prevent body to produce simple sugar (9). Alkaloids, tannins, phenolic derivatives, and flavonoids are examples of antioxidants (10). Insulin secretion is also stimulated by phenolic flavonoids. Tannins and flavonoids can block the action of α-glucosidase, which lowers the amount of glucose absorbed and increases in the digestive system (11,12). Diabetes mellitus (DM) is a chronic disorder characterized by hyperglycemia (high sugar levels). Dysfunction in the functioning of insulin may give rise to poor glucose, lipid, and protein metabolism, causing DM illness. Insulin insufficiency can be caused by disruption or deficiency of insulin production by Langerhans beta cells of the pancreas gland or by the body's cells being less responsive to insulin (5). The number of patients with diabetes mellitus (DM) per year has increased due to changes in humans' environment, behavior, and lifestyle.

Dietary interventions derived from natural resources have been identified as having the potential to control sugar levels in people with diabetes. Herbal plants can be utilized to synthesize drugs to treat diabetes mellitus (13–15). Plants are a rich source of constituents with antidiabetic and antioxidant properties, such as flavonoids, gallotannins, amino acids, and other polyphenolics (16–18). In addition, plants with antihyperglycemic activity are more desirable because they have fewer side effects and are cheaper (19). Considering the chemical compounds contain in coffee leaves, it can be developed further as a functional beverage to add value to the existing coffee leaf usage.

2. Materials and Methods

2.1. Materials

Old robusta coffee leaf from Ampelgading and Ngantang districts and old arabica coffee leaf from Karangploso district. Old coffee leaf was harvested within 5-8 coffee plant branchs. In addition, commercial oolong tea from the *Camellia sinensis* plant is also used, which is obtained from supermarkets. All samples were brewed using mineral water at a ratio of 1:100 at 80°C for 3 minutes with the soft infusion method.

2.2. Processing Coffee Leaf Tea and Phytochemical Analysis

The coffee leaf used is old coffee leaf (strands 5–8), then sorted, washed, and dried. Coffee leaf is rolled and sliced into small pieces before being withered for 12 hours at 25°C and dried in an electric oven at 70°C for 4 hours. After drying, the coffee leaf is mashed for 31 minutes with a dry blender at 3000 rpm. Coffee leaf tea powder is stored in a dry and closed container. All tea samples were brewed using the soft infusion method (80°C, 3 minutes). Tea brewing is carried out by quantitative analysis of phytochemicals for total phenolic, flavonoid, tannin, sugar total, and antioxidant activity (20–23).

2.3. Ethics Statement

Animal care and all experimental procedures were approved by the Animal Care and Use Committee, Brawijaya University (Approval no.080-KEP-UB-2020).

2.4. In Vivo Test

Healthy Wistar rats aged 2.5–3 months (150–200 grams), not anatomically deformed, and actively mobile were utilized in this experiment. After an adaptation period of 7 days, all rats fasted overnight for 12 hours, and their initial fasting blood glucose levels were measured to ensure that the rats were healthy and did not develop diabetes. Measurement of blood glucose levels used the biosensor glucose oxidase method with a blood glucose test meter (*Easy Touch GCU Meter ET-301*) and a glucose test strip (*Easy Touch GTS Code: 2477*). Then, for diabetes mellitus treatment, rats were induced with STZ intraperitoneally at a dose of 80 mg/kg body weight (24). STZ was dissolved in citric acid at pH 4.5. Rats were generally maintained for 3 days. On the third day after induction, rats' blood sugar levels were measured after being fasted for 12 hours (rats were only allowed to drink *ad libitum*). Rats will experience hyperglycaemia if their fasting blood sugar level exceeds 200 mg/dL(25), and rats are suitable for use as experimental animals. Thirty-five rats were divided into 7 treatment groups, namely T0 (negative control), T1 (positive control), and T2 (glibenclamide control). T3 (DM rat + oolong tea), T4 (DM rat + Ampelgading Robusta coffee leaf tea), T5 (DM rat + Ngantang Robusta coffee leaf tea), and T6 (DM rat + Karangploso Arabica coffee leaf tea), Sample doses used were 12 mL/kg/day and were given for 28 days. The rat will be checked for fasting blood sugar and body weight each week. After 28 days of treatment, immunohistochemical tests and HE staining were performed on the pancreatic tissue.

2.5. Sensory Analysis

Sensory analysis was performed using the Rate-All-That-Apply (RATA) method to determine the sensory attributes and intensity of the sensory attributes of a product by using untrained panelists (26). The sample was poured into a paper cup and given a random three-digit code. The panelist was given 4 cups (4 different samples), mineral water, and plain crackers as a palate cleanser during a sensory evaluation. Panelists will provide an assessment of the questionnaire that has been given.

2.6. Data Analysis

Data was analyzed as ANOVA by Minitab 17 application. If there was a significant difference in the p-value <0.05, the Fisher test was carried out with a 95% confidence interval to determine the effect of each treatment.

3. Results and Discussion

3.1. Phytochemical Analysis

Coffee leaf tea with different types and growth sites can affect the composition of the brewed tea. According to Table 1, there are differences in all parameters of the chemical components of oolong tea and Arabica tea. Karangploso coffee leaf tea, Robusta Ampelgading, and Robusta Ngantang. Except tannin content, oolong tea tended to have higher phytochemicals (Table 1). It may be affected by the fact that commercial oolong tea was proceeded from young leaf (tea buds), while the coffee leaf tea was proceeded from old leaf. This condition in accordance with prior research that old leaf may have lower concentration of phytochemicals (27).

Table 1. Chemical Characteristics of Oolong Tea and Oolong-like Coffee Leaf Tea.

Analyte	Oolong tea	Arabica Karangploso	Robusta Ampelgading	Robusta Ngantang
Total Phenolic (mgGAE/g)	94.64 ± 0.56^{a}	44.60 ± 0.78^{c}	56.53 ± 0.43^{b}	36.59 ± 0.05^{d}
Tannin content (mgTAE/g)	46.36 ± 0.12^{a}	39.59 ± 0.30^{b}	45.24 ± 0.12^{a}	35.34 ± 0.81^{c}
Flavonoid (mgQE/g)	57.04±0.29^{a}	35.03 ± 0.16^{c}	47.35 ± 0.12^{b}	29.40 ± 0.91^{d}
Antioxidant activity (%)	56.63 ± 0.36^{a}	49.46 ± 0.62^{c}	54.96 ± 0.41^{b}	50.18 ± 0.36^{c}
Total sugar (%)	0.137 ± 0.002^{a}	0.124 ± 0.002^{b}	0.103 ± 0.001^{c}	0.100 ± 0.003^{c}

Based on Table 1, it can be seen that there are differences in all parameters of the chemical components of oolong tea, Arabica Karangploso coffee leaf tea, Robusta Ampelgading, and Robusta Ngantang. Coffee plant productivity is affected by environmental conditions, specifically the height of the location and the type of rainfall. Therefore, the type of coffee planted must be adjusted to the conditions of the altitude and rainfall in the local area (24).

According to test results, coffee leaf tea derived from the Robusta variety of Ampelgading contains the highest total phenolic, tannin content, total flavonoid, and inhibition activity compared to other types of coffee leaf tea. Ampelgading's Robusta coffee is grown on Mount Semeru, which has a land elevation of 1500 meters above sea level. Arabica Karangploso is located at 1200 meters. Robusta Ngantang is located at 720 meters above sea level. The better the soil's geographical conditions, the more bioactive components are contained in plants. Various factors, such as regional geography, environmental conditions, species, cultivars, plant age, leaf development stage, and harvest season, have an influence on the phytochemical composition of coffee leaf (28).

3.2. Comparative Effect of Coffee Leaf Tea, Oolong Tea and Glibenclamide On Blood Glucose Level

Treatment of experimental animals consisted of giving Robusta Ampelgading, Robusta Ngantang, Arabica Karangploso coffee tea leaf, commercial oolong tea, and glibenclamide. The results of changes in blood glucose levels each week can be seen in Table 2.

The results of measuring fasting blood glucose in rats for 28 days revealed variable conditions. At the end of the treatment period (the 28th day), the T3-T6 treatment group showed a decrease of blood glucose level. In the diabetes mellitus (T1) group, blood glucose levels increased at the end of the treatment due to the inability of endogenous antioxidant enzymes to fight exposure to free radicals, which are factors causing damage to pancreatic beta cells as insulin-producing cells. Hyperglycemia conditions that last a long time can trigger an increase in the formation of ROS (*reactive oxygen species*) by various mechanisms, such as glucose autoxidation and protein glycation, so that oxidative stress will occur (29).

Decreasing fasting blood glucose levels until the end of treatment occurred in a group of DM rats treated with oolong tea, Robusta Ampelgading, Robusta Ngantang, and Arabica Karangploso. Blood glucose levelswas decreased due to bioactive compounds in oolong and coffee leaf teas, such as phenolics, tannins, and flavonoids which can act as antioxidants and fight free radicals by preventing a chain reaction of converting superoxide into hydrogen superoxide by donating hydrogen atoms from the aromatic hydroxyl (-OH) group to bind free radicals, so they will provide a protective and repair effect on defective pancreatic beta cells.

Repair of pancreatic beta cells can increase insulin secretion again to reduce high blood glucose levels (30).

Table 2. Weekly changes in the blood glucose levels during experiment.

Treatment	Blood Glucose Level (mg/dL) Day-					changing (%)
	1	7	14	21	28	
Negative control (T0)	115.4 ± 15.13^{c}	123.6 ± 23.27^{c}	118.4 ± 12.89^{d}	113 ± 40.59^{c}	137 ± 55.15^{e}	18.71
Positive control (T1)	463.5 ± 45.14^{b}	396.33 ± 62.07^{b}	363 ± 264.45^{c}	246 ± 171.12^{b}	411 ± 0^{c}	-11.33
Glibenclamide (T2)	479.6 ± 69.78^{b}	444.33 ± 38.55^{ab}	449.5 ± 19.09^{abc}	484 ± 0^{a}	484 ± 0^{a}	0.91
Oolong tea (T3)	433.25 ± 41.03^{b}	466.75 ± 81.57^{ab}	382.33 ± 187.75^{bc}	309 ± 268.70^{b}	283 ± 0^{d}	-34.68
Robusta Ampelgading (T4)	540.25 ± 69.05^{a}	489.25 ± 76.79^{a}	515 ± 41.94^{a}	580.33 ± 23.71^{a}	467.67 ± 8.08^{ab}	-13.43
Robusta Ngantang (T5)	464.75 ± 92.52^{ab}	449 ± 61.95^{ab}	505 ± 88.67^{ab}	442.33 ± 117.50^{a}	426.33 ± 49.22^{bc}	-8.27
Arabica Karangploso (T6)	348 ± 170.13^{b}	450.75 ± 69.80^{ab}	472.5 ± 29.09^{abc}	469 ± 78.23^{a}	459.33 ± 38.68^{ab}	31.99

In the DM group, glibenclamide (T2) treatment did not significantly reduce fasting blood glucose levels in rats. Because the islet of Langerhans contained in pancreatic beta cells is thought to have been damaged as a result of too much STZ induction, glibenclamide treatment cannot help increase insulin release in pancreatic beta cells. Glibenclamide lowers blood sugar levels by increasing insulin release from the pancreas. Sulfonylurea in glibenclamide binds to pancreatic beta cells and triggers exocytosis (secretion) of insulin. Another effect is to inhibit triglyceride lipases.

In the Karangploso Arabica coffee leaf tea group, the fasting blood sugar of rats increased from day 1 to day 14. This was because the Karangploso Arabica coffee leaf contained mangiferin compounds not found in Robusta coffee leaf. In Arabica coffee leaf, the composition of mangiferin is 2.222 ± 0.236 mg/g with a bioavailability value of 1.2% (31,32) (25,26). At this rate and amount, mangiferin was unable to reach the molecular target to increase the inhibition of alpha-glucosidase as a hydrolyzing enzyme because mangiferin has low lipophilicity and intestinal permeability (30,31). In a prior study, mangiferin extract as an antidiabetic at a dose of 10 mg/kg BW could reduce glucose by 95.3% (18). On the 21st day, mangiferin had a positive effect on antidiabetics, marked by a decrease in blood glucose. This is presumably because the mangiferin compound in the body has accumulated since the 14th day to provide an antihyperglycemic effect.

3.3. Comparative Effect of Coffee Leaf Tea, Oolong Tea and Glibenclamide On Body Weight

Based on Table 3 Diabetic treatment Rats' body weight decreased at the beginning of the treatment period. Weight loss is one of the characteristics of diabetes mellitus, where the body tends to get energy from the process of breaking down fat (33). Diabetes is characterized by the inability of the body to use blood sugar as an energy source, so that energy is obtained from other pathways in the form of fat breakdown. As a result, DM sufferers tend to experience weight loss. Weight loss in people with diabetes can also be caused by protein breakdown(34).

Table 3. Weekly changes in the body weight during experiment.

Treatment	Body Weight Level (gram) Day-					Changing (%)
	1	7	14	21	28	
Negative control (T0)	131 ± 4.90^{b}	124.8 ± 11.92^{b}	110.4 ± 25.17^{a}	130 ± 10.81^{a}	145 ± 0^{bc}	10.68
Positive control (T1)	170.5 ± 14.98^{a}	150 ± 18.52^{ab}	138.5 ± 47.38^{a}	132.5 ± 44.54^{a}	200 ± 0^{a}	17.30
Glibenclamide (T2)	177.6 ± 24.13^{a}	160 ± 14.10^{a}	141 ± 16.97^{a}	120 ± 0^{a}	135 ± 0^{c}	-2.99
Oolong tea (T3)	163 ± 14.72^{a}	147.5 ± 18.84^{ab}	136.33 ± 25.03^{a}	130 ± 30.09^{a}	172 ± 0 ^{ab}	5.52
Robusta Ampelgading (T4)	163 ± 7.39^{a}	148.25 ± 4.03^{ab}	129.33 ± 2.08^{a}	121 ± 6.24^{a}	124 ± 2^{c}	-23.93
Robusta Ngantang (T5)	174.6 ± 19.65^{a}	153 ± 13.29^{a}	132.5 ± 29.21^{a}	128.67 ± 26.16^{a}	130 ± 30.51^{c}	-25.54
Arabica Karangploso (T6)	184 ± 18.67^{a}	160.25 ± 24.29^{a}	137 ± 51.12^{a}	133.3 ± 43.92^{a}	139.67 ± 56.72^{c}	-24.09

Based on Table 3, Insulin resistance disrupted fat distribution which was causing weight gain in the positive control. Individuals with diabetes or insulin resistance will store body fat in the abdomen and chest (35). In addition, insulin resistance can inhibit the proteolysis process (36).

Groups of rats that were given coffee leaf tea samples, and a group of rats given glibenclamide as a controlled drug for 28 days experienced weight loss compared to the first day. DM conditions can cause weight loss due to excessive protein degradation in organs (37). On the 28th day, the rat group with the oolong tea treatment experienced increased body weight accompanied by a decrease in blood glucose levels. Oolong tea has antioxidant activity, which increases insulin production, so blood glucose levels decrease in oolong tea samples. Increased insulin sensitivity causes GLUT-4 to activate so blood glucose can be absorbed by peripheral tissue cells, and cells will use glucose as an energy source and convert excess glucose into glycogen. In addition to the presence of antioxidant activity, weight gain can also be influenced by flavonoid compounds that play a role in stimulating lipogenesis and glucose transport in rat adipocytes. Flavonoid compounds have therapeutic potential in the treatment of diabetes by stimulating glucose uptake in the absence of fully functional insulin receptors (33).

3.4. Histopathological Assessment of The Pancreas

Based on Figure 1 The number of pancreatic beta cells that are immunoreactive to anti-insulin in the DM group after giving Ampelgading Robusta (T4), Ngantang Robusta (T5), and Karangploso Arabica (T6) showed lower numbers than the DM (T1) and DM groups after treatment with oolong tea (T3). The same thing happened to the diabetes treatment group treated with glibenclamide. The standard group (T0) had the highest beta cells, with 104.67 cells per field of view. Normal Langerhans islets are characterized by the presence of round or oval areas that are not encapsulated with pale color in the lobules of the pancreas and are composed of irregular and branched groups of cells separated by blood capillaries (38). Overall, based on statistical calculations, the mean number of beta cells in the islets of Langerhans showed a significant difference because they had different notations.

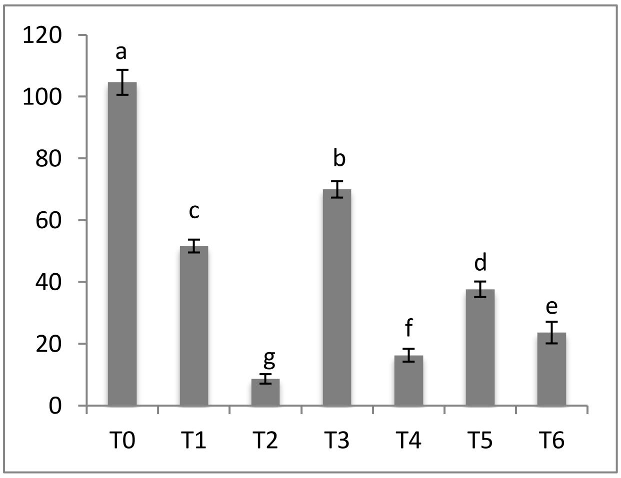

Figure 1. Average of β-Cells in Langerhans Islet (*p-value*<0.05).
T0= Negative control; T1= Positive Control; T2= Glibenclamide treatment; T3= Oolong tea; T4= Robusta Ampelgading; T5= Robusta Ngantang; T6= Arabica Karangploso.

Pancreatic beta-cell damage can be observed by immunohistochemical staining and counting the number of pancreatic beta cells and the endocrine activity of islet Langerhans cells (39). The color change in immunohistochemistry occurs due to a specific reaction between antibodies to the insulin hormone on Langerhans islet cells to distinguish them from beta cells that do not produce insulin. Positive insulin expression on immunohistochemistry is seen in the form of dark brown granules present in the cytoplasm of beta cells. In the negative control group (Figure 2a), dark brown granules were very large and almost filled the entire Langerhans islet. This is comparable to the typical results of detected blood glucose. The DM group (Figure 2b-g) showed a low brown grain area, more diminutive and irregular size, and more Langerhans islets than the negative control. The condition of an extreme increase in blood sugar causes the pancreatic beta cells to have difficulty secreting insulin, such as in the DM group treated with glibenclamide (Figure 2c). In the oolong tea (Figure 2d), Robusta Ampelgading (Figure 2e), Robusta Ngantang (Figure 2f), and Arabica Karangploso (Figure 2g) groups, the area is unequal.

When adjusted for blood glucose levels (Table 2), oolong tea with the lowest fasting blood glucose value showed a dense brown grain area. Although there was an increase in fasting blood sugar, the four samples were able to help lower blood glucose levels because they had high antioxidant activity (Table 1). Antioxidant compounds will help repair and increase the number of pancreatic beta-cells by inhibiting oxidative stress after donating electrons to free radicals (28).

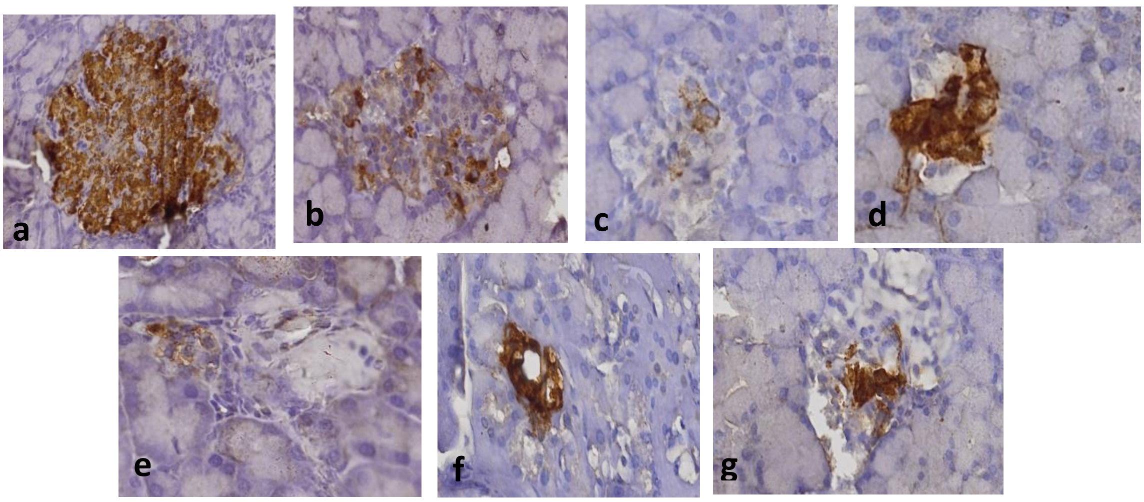

Figure 2. Photomicrograph pancreas stained with immunohistochemical.
a. Negative control (T0); b. Positive Control (T1); c. Glibenclamide treatment (T2); d. Oolong tea (T3); e. Robusta Ampelgading (T4); f. Robusta Ngantang (T5); g. Arabica Karangploso (T6).

3.5. Fasting Blood Glucose and Number of Beta-Cells Correlation

A significant inverse correlation was found between the fasting blood glucose level and the number of beta cells (R: -0.973 and p-value <0.05), where the higher the fasting blood glucose level, the lower the number of beta cells. A decrease in beta cells can cause insulin secretion disorders so that fasting blood sugar levels cannot be controlled (40). Robusta Ampelgading showed that the number of pancreatic beta cells was higher than with glibenclamide. This is comparable to fasting blood sugar in Robusta Ampelgading, which shows a greater decrease than glibenclamide. Robusta Ampelgading bioactive compound repaired pancreatic beta cells. Bioactive compounds prevent the formation of free radicals and provide a protective and repair effect on damaged pancreatic beta cells.

3.6. Comparative Effect of Oolong Tea and Oolong-Like Coffee Leaf Tea On Sensory Att Ributes

Based on the results of the sensory tests (Figure 3), panelists felt a different intensity of bitter taste for the four samples tested. Panelists felt the most vital bitter sensation in the oolong tea samples. Each type of tea has a distinct bitter taste with a different intensity, and the emergence of a bitter taste is caused by the polyphenolic and tannin components, which are closely related to the mouthfeel (tangy, astringent).

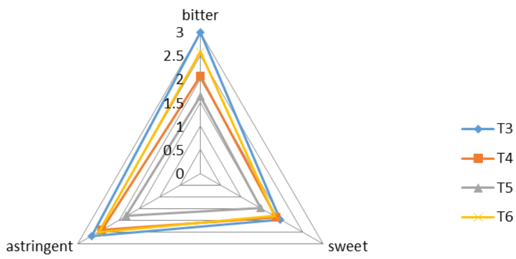

Figure 3. Comparisons of Astringency, Bitterness, and Sweetness of Oolong Tea and Oolong-like Coffee Leaf Tea.
T3= Oolong tea; T4= Robusta Ampelgading; T5= Robusta Ngantang; T6= Arabica Karangploso

One of the causes of the astringent mouthfeel in tea drinks is the phenolic group. This astringent mouthfeel causes a scratchy sensation on the tongue when consuming tea. Polyphenolic components influence the sensory profile of a food product. These polyphenolics can cause an astringent sensation in tea, fruit juice drinks, and food products (41). According to the four samples tested, the data obtained showed that the panelists showed differences in mouthfeel for the four samples. Sugar compounds cause the sweet taste in tea drinks. As a result, the results of the panelists' sensory tests show that the four samples tend to have the same intensity of sweetness.

The Pearson's correlation analysis of sensory attributes with bioactive compounds showed (Table 4) that there is a strong correlation between tannin and bitterness, sugar total and sweetness, and total phenolic and astringency. Tannin affects the assessment of bitter attributes by 44.1%, and the rest is influenced by other factors. Other research has found that tannins, as well as stereochemistry and isoflavones, can provide bitter taste attributes (42). Although it has a higher tannin content, Robusta Ampelgading shows a lower bitter value than Arabica Karangploso.

Robusta coffee leaf contains amino acids that have a sweet flavor, so that affected the panelists' assessment. Likewise, the results of the sweet assessment attribute show that Robusta Ampelgading has a lower total value than Arabica Karangploso. On the contrary, because of the amino acids' presence in Robusta Ampelgading and their ability to influence a sweet flavor, the panelists can feel a sweet sensation in Robusta Ampelgading. A strong positive correlation was observed between total phenolic and astringency. Prior research has shown that the presence of phenolic in wine affects the perceived astringency attribute (43).

Table 4. Correlation of sensory attributes with bioactive compounds.

a. Total Phenolic Compound with Astringent

Sample	Total Phenolic Compound	Astringent	*R-value*
Oolong tea (T3)	94.64	2.67	0.744
Robusta Ampelgading (T4)	56.53	2.49	
Robusta Ngantang (T5)	36.59	1.82	
Arabica Karangploso (T6)	44.60	2.41	

b. Tannin Content with Bitter

Sample	Tannin Content	Bitter	*R-value*
Oolong tea (T3)	46.36	3.00	0.664
Robusta Ampelgading (T4)	45.24	2.06	
Robusta Ngantang (T5)	35.34	1.63	
Arabica Karangploso (T6)	39.59	2.57	

c. Sugar Total with Sweet

Sample	Sugar Total	Sweet	*R-value*
Oolong tea (T3)	0.137	1.96	0.712
Robusta Ampelgading (T4)	0.103	1.86	
Robusta Ngantang (T5)	0.100	1.47	
Arabica Karangploso (T6)	0.124	1.82	

4. Conclusions

Robusta coffee leaf tea was able to reduce fasting blood glucose by 13.43%, meanwhile oolong tea was able to reduce fasting blood glucose about 34.68%. However, Robusta Ampelgading's sensory quality is better than oolong tea because of its lower bitterness and highly similar sweetness level. Even though Robusta Ampelgading ability to lower blood glucose levels is about half that of oolong tea, it still has the potential to be developed in the future with a higher sensory level and increased dosage. We suggest to identify other bioactive compounds such as alkaloids, xanthones, and organic acids that act as therapeutic agents for diabetes mellitus in Robusta and Arabica coffee leaf tea in order to build more profound knowledge in future research. It is necessary to carry out an in vivo test by reducing the induction dose of streptozotocin and increasing the volume of Robusta and Arabica coffee leaf tea to optimize the resulting therapy in further research.

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Author Contributions

K.F. and E.M. conceived and designed the experiments as well as partially wrote the paper; A.I. contributed reagents/materials/analysis tools, performed the experiments and analyzed the data; I.A.B. result interpretation, manuscript proofreading.

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Institutional Review Board Statement

This research was approved by the Ethical ommitee of Universitas Brawijaya 080-KEP-UB-2020 and July 30th 2020 for animal protocol and antidiabetic properties.

This research was conducted in Universitas Brawijaya and approved by the Institutional Review Board or the Ethics Committee of State Polytechnic Of Health Malang with protocol code 388/KEPK-POLKESMA/2019 and August 19th 2019 for human organoleptic herbal tea test.

Data Availability Statement

The data that support the findings of this study are available at https://bit.ly/ResearchDataCoffeeLeafTea.

Conflicts of Interest

No conflict of interest.

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