Indonesian Journal of Applied Research IJAR

Exploring the Sensory Profile of Stevia Coffee Using Rate-All-That-Apply (RATA) Method and Chemical Analysis

Elsera Br Tarigan[1], Cindy Amelia Hardianti[2], Muhammad Rifqi[2]

[1]Research Center for Pharmaceutical Ingredient and Traditional Medicine, National Research and Innovation Agency Indonesia, Indonesia
[2]Food Technology and Nutrition Faculty of Halal Food Science, Universitas Djuanda, Indonesia

Volume 5 Issue 1
(April 2024)
e-ISSN 2722-6395
doi: 10.30997/ijar.v5i1.454

ARTICLE INFO

Article history:
Received: 02-01-2024
Revised version received: 02-06-2024
Accepted: 04-19-2024
Available online: 04-30-2024

Keywords:
beverages; consumer profiling; organoleptic; robusta; safe sweetener

How to Cite:
Tarigan, E. B., Hardianti, C. A., & Rifqi, M. (2024). Exploring the Sensory Profile of Stevia Coffee Using Rate-All-That-Apply (RATA) Method and Chemical Analysis. *Indonesian Journal of Applied Research (IJAR)*, *5*(1), 48-63. https://doi.org/10.30997/ijar.v5i1.454

Corresponding Author:
Elsera Br Tarigan
elseraborutarigan@gmail.com

ABSTRACT

Coffee is usually consumed by adding sugar, cream, or milk. Adding these ingredients, especially sugar, can cause new disease problems. The market is starting to look for natural sweeteners that do not cause health problems, such as stevia. The objective of this research was to identify the sensory attributes and chemical components of some variety of stevia coffee formulations. Sensory attributes were identified through a focus group discussion (FGD), and sensory profiling to choose the best formulation was determined using the Rate-All-That-Apply (RATA). The FGD members were nine panelists, while the RATA sensory evaluation used 30 panelists. Chemical analysis carried out includes water (gravimetry), ash (gravimetry), and antioxidant capacity (spectrophotometry). In this research, four distinct formulations of stevia coffee, A1 (0% stevia), A2 (2% stevia), A3 (4% stevia), and A4 (7% stevia), were utilized. Results indicate that varying stevia concentrations significantly influence the resulting coffee's sensory characteristics. Attributes identified through FGD include color (dark brown), aroma (green/leafy, sour, roasted, spicy), taste (acid/sour, sweet, bitter, green, spice) and aftertaste (over, bitter and sweet). Statistical analysis showed that eight out of thirteen sensory attributes had significant differences ($p<0.05$) among the four samples. Sensory evaluation of the selected sample, A2 (4%), revealed a favorable taste profile characterized by sweetness and sourness. Moreover, the chosen formulation exhibited a notable antioxidant activity level of 83.13%. These findings underscore the potential of stevia coffee as a flavorful and health-conscious alternative, offering valuable insights for product development and consumer acceptance.

1. Introduction

Coffee is the second most widely consumed beverage globally and has become a lifestyle of the day (Gaascht et al., 2015). Indonesia produced 774.69 thousand tons of coffee in 2021. This supply comes from 1.26 million hectares of coffee plantations. Robusta coffee is the most widely produced kind in Indonesia, according to a review of coffee varietals grown there. More specifically, from 2013 to 2022, robusta coffee made up 73.00% or 508.33 thousand tons, while arabica coffee accounted for the remaining 27.00% or 187.98 thousand tonnes. The provinces of South Sumatra, Lampung, Bengkulu, East Java, and Central Java have been the average locations for the production of robusta coffee in Indonesia over the past five years. From 1993 to 2021, Indonesia's per capita consumption of ground coffee at home is expected to rise by 1.52% annually (Pusat Data dan Sistem Informasi Pertanian, 2022). Globalization drives Indonesia's coffee consumption increase, resulting in a burgeoning industry with dynamic competition, fostering innovation within the sector (Safitri & Arina, 2022). Coffee is becoming increasingly popular because of its flavor, simplicity of preparation, affordability, and psychological effects; robusta coffee, in particular, has volatile chemicals from alcohols, ketones, and esters (Zhang et al., 2022). The chemical characteristic of green Robusta coffee showed higher values for soluble solids, pH, caffeine, total caffeoylquinic acid, total feruloyl quinic acid, and total caffeoylquinic acids than Arabica coffee (Bicho et al., 2013). These bioactive substances possess antioxidant properties that could help avoid some degenerative illnesses (Herawati et al., 2019).

Regular coffee consumption has positively impacted various health aspects, including liver function, neurological and metabolic disorders, and cognitive responses (Jeon et al., 2019). Coffee consumption for a long-term period could reduce the prevalence of type 2 diabetes mellitus (de Oliveira et al., 2014). On the other hand, other individuals drink coffee with creamer and additional sugar. When Turkish coffee was boiled, adding sugar decreased the amount of polyphenols and antioxidant activity (Nakilcioğlu-Taş, 2018). A compelling investigation was presented in 2017, revealing a correlation between the regular intake of instant coffee blends among Korean females and an elevated incidence of obesity (Lee et al., 2017). Thus, the market has started to research natural sweetening agents to mitigate the impacts of sugar, but they are still acceptable. One of the sweeteners that is considered safe is stevia (Dwivedi & Tomer, 2018). Stevia is still limited to single or mixed tabletop dosage forms and cannot be used as an artificial sweetener food additive in processed food products (Limanto, 2017).

Customer happiness is crucial for repeat business and loyalty. Understanding consumer preferences and needs is essential for product development. Businesses must comprehend consumer perceptions, demand formation, and factors influencing product choices (Adawiyah & Yasa, 2017; Ares et al., 2014). Sensory profiling is a popular method for assessing customer preferences, using techniques like rate-all-that-apply (RATA) and check-all-that-apply (CATA). CATA evaluates food product characteristics, while RATA assesses product characteristics and chosen qualities. Rate-All-That-Apply (RATA) provides quick customer opinions (Adawiyah et al., 2020; Kim et al., 2023).

According to the Food and Drug Administration (FDA), stevia is generally considered safe (GRAS), meaning it could be the safest artificial sweetener available. However, stevia is usually more expensive than regular sugar, and it has a few small side effects, like bloating and nausea. More important are its unique licorice flavor and mildly bitter aftertaste, which are features that most customers find disagreeable (Dwivedi & Tomer, 2018). Keefer et al. (2020) identified the sensory attributes of bars made with stevia as bitter and metallic, with a sweet aromatic and cardboard taste. It is anticipated that incorporating stevia into coffee could serve as an alternative to sugar, prompting a need to investigate the sensory characteristics of stevia coffee that remain palatable to consumers. The objective of this research was to identify the sensory attributes and chemical components of some variety of stevia coffee formulations.

Sensory attributes were identified through a focus group discussion (FGD), while sensory profiling to choose the best formulation was determined using the Rate-All-That-Apply (RATA). The chemical components, moisture, and ash content were analyzed using the SNI 8964:2021 procedure.

2. Methods

2.1. Materials

Robusta coffee was planted in the Indonesian Industrial and Beverage Crops Research Institute (IIBCRI), Ministry of Agriculture Republic Indonesia experimental garden in Pakuwon, stevia leaf powder from online retailers, and bottled water. The study utilized the following equipment: roasters (Toper), analytical scales, spoons, spatulas, plastic, filter paper, glasses, labels, stationery, and other auxiliary equipment.

2.2. Method

This research was conducted in several stages: (1) formulation of stevia coffee with several concentrations, (2) focus group discussion (FGD), (3) selection and determination of panelists, (4) sensory analysis, and (5) data analysis. This research also carried out chemical tests, including moisture content, ash content, and antioxidant activity, using the DPPH method. The analyses carried out were Friedman's test, Principal Component Analysis (PCA), and Preference Mapping using the XLSTAT by the Addinsoft 2022 application. Friedman's test aims to identify significant differences between samples for each sensory attribute (Ares et al., 2014). Further analysis, Nemenyi’s, was conducted if the p-value was less than 5%. The correlations and similarities between interrelated observations were determined using the PCA. The output of this analysis was a biplot graph that describes the sensory profile of stevia coffee (Abdi & Williams, 2010). Preference Mapping shows the panelist's preference map for the stevia coffee product being tested. Preference Mapping data analysis produced a 2-dimensional contour plot describing information about products consumers like and do not like.

2.2.1 sample Preparation

Briefly, the coffee cherry was sorted, peeled, fermented, washed, and husked. Furthermore, the green beans were roasted on a medium level. The roaster temperature condition was 200°C for 5 minutes, and ground it till fine. Stevia leaf powder was added to coffee in four concentrations (A1 0%, A2 4%, A3 7%, and A4 10%) and mixed well.

2.2.2. Focus Group Discussion (FGD)

The prerequisites for organizing a Focus Group Discussion (FGD) include the requirement that the size of panelists consist of 8-12 individuals partake in the session (Djekic et al., 2021; Kempf et al., 2010). This study used nine panelists. They were five men and four women. The panelists were the IBCRI employees (7) and others (2) from outside who were familiar with the coffee attributes and non-smokers. All the members were categorized as semi-trained panelists since their jobs were related to coffee. FGD was conducted in IBCRI Café. A brief introduction to stevia coffee products and the primary ingredients (coffee and stevia) was given to FGD members. FGD was conducted before sensory profiling to collect the attributes of stevia coffee. The descriptive sensory attributes included the color, aroma, taste, and mouthfeel. FGDs were performed to verify the attributes of stevia coffee. Furthermore, those attributes were implemented in descriptive analysis through Rate-All-That-Apply (Adawiyah et al., 2020).

2.2.3. Selection of Panelist

The inclusion criteria of the panelists of this research were 15–60 years old, men or women, and coffee drinkers. During the panelist recruitment phase, the questionnaire was designed to collect demographic data from consumers, specifically focusing on their gender, age, and background. There were 30 non-trained panelists in this research; 12 were women, and 18 were men.

2.2.4. Sensory Profiling by RATA Technique

Sample tests were labeled with three-digit random numbers. Stevia was added to the coffee, mixing well, and placed in a storage box. Briefly, 10 g of stevia coffee was brewed using 150 mL of hot water at 95oC by Tubruk technique. The sample was incubated for four minutes at ambient temperature. First, panelists were asked to consume water to neutralize their senses. Subsequently, the panelists start to taste and assess the preference of each sample using the Likert scale. From one sample to another, the panelist should gargle using mineral water. The scale was between 1-6:1=dislike very much, 2=dislike, 3=slightly dislike, 4=slightly like, 5=like, 6=like very much. Further, the panelists rate the intensity of each attribute by placing a checklist on the attribute intensity form. The intensity rate was 1-5 (1 = very low, 2 = slightly low, 3 = moderate, 4 = slightly high, and 5 = very high). Suppose the panelists could not identify any attributes outlined in the sample Table description. In that case, the attribute may be inserted into the empty left column and assigned a value of zero (0). The compilation of sensory attributes was derived from the Focus Group Discussion (FGD).

2.2.5. Chemical analysis

The parameters tested were moisture content, ash, and antioxidant content. Water and ash contents are determined based on the gravimetry method (BSN, 2021), while antioxidants are based on DPPH (2,2-diphenyl-1-pikrilhidrazyl) (Niah & Baharsyah, 2018).

a. Moisture content (BSN, 2021)

The crucible underwent a drying process within an oven set at a temperature of 105°C for 15 minutes, subsequently undergoing a cooling phase within a desiccator. The initial weight of the crucible was determined, followed by adding 1 gram of coffee stevia. Subsequently, the crucible was placed inside an oven set at a temperature of 105 degrees Celsius for 3 hours. The sample was removed and subjected to cooling within a desiccator, followed by subsequent weighing. The process of drying was reiterated until a consistent mass was achieved. Calculation of water content was carried out using the formula:

$$Moisture\ content = \frac{\mathrm{c} - \mathrm{d}}{\mathrm{b}}\ x\ 100\%$$

b = Sample weight

c = Weight of crucible + initial sample

d = Weight of crucible + final sample

b. Ash content (BSN, 2021)

The porcelain crucible undergoes a heating process in the oven for 15 minutes, followed by a cooling phase in a desiccator before being weighed. Subsequently, a sample of 3-5 grams was weighted. The sample was placed within a porcelain crucible and weighed, then subjected to combustion until no smoke was emitted, and finally ashed in a kiln at a temperature of 550ºC until achieving a white color (sample typically transitions to a gray hue) and reaching a consistent weight. Furthermore, the sample was cooled within a desiccator and weighed again.

$$Ash\ content = \frac{w1 - w2}{\mathrm{w}}\ x\ 100\%$$

w: Sample weight (g)

w1: Weight of sample + crucible pocelain after ashing (g)

w2: Weight of empty crucible pocelain (g)

c. Antioxidant Capacity (Niah & Baharsyah, 2018)

The assessment of antioxidant capacity was conducted using the DPPH (1,1-diphenyl-2-picrylhydrazyl) method. Briefly, 0.2 mL of brewed stevia coffee was introduced into a test tube, followed by a 3.8 mL of solution containing DPPH (0.004 mg in 100 mL methanol). The resulting mixture was then subjected to homogenization using a vortex. Prepare a positive control solution by combining 0.2 mL of methanol with 3.8 mL of DPPH solution. All experimental samples and control solutions were placed in a light-sealed chamber at room temperature for 60 minutes for 1 hour. The absorbance was determined via UV-visible spectrophotometry at a specific wavelength of 517 nm. The assessment of antioxidant capacity involves the computation of the percentage absorbance value through a defined mathematical expression. This formula is expressed as follows:

$$\text{Antioxidant capacity (\%)} = \frac{(Ab - As)}{\mathrm{Ab}}\ x\ 100\%$$

Ab = the blank absorbance value,

As = the absorbance value of the sample solution.

3. Results and Discussion

3.1. Focus Group Discussion (FGD)

The sensory description analysis of stevia coffee was carried out by searching the lexicon (sensory language) and measuring the intensity of the sensory attributes of stevia coffee. The lexicon of coffee stevia was obtained through FGD, shown in Table 1. Hayakawa et al. (2010) developed the terminology lexicon of coffee was categorized into three distinct groups, "taste," "aroma," and "mouthfeel," with descriptors for both orthonasal and retronasal categorized as "aroma." Meanwhile, this study classified the attributes into appearance, aroma, taste, and aftertaste. This vocabulary facilitates uniformity of taste perception among stevia coffee panelists, regardless of background, culture, age, and gender, thereby helping to establish a common terminology for assessing coffee taste (Panagiotou & Gkatzionis, 2022).

Based on the group discussion, stevia coffee had 13 lexicons, which refers to SCAA (2015). Table 1 presents each attribute's description. Emotion lexicons aid in this stevia coffee-evoked emotion measurement. Original coffee has 24 lexicons: bitter, sour, salty, coconut, apple, pineapple, grape, acetic acid, isovaleric acid, butyric acid, peapod, fermented, fresh, musty/earth, papery, moldy/damp, musty/dusty, petroleum, phenolic, almond, brown spice, floral, vanillin, and jasmine. The objective behind developing this coffee lexicon is to provide a valuable resource for traders, roasters, baristas, and producers, aiming to enhance quality control measures and educational practices within the coffee sector (World Coffee Research, 2017).

Table 1 shows the flavor lexicon of stevia coffee from FGD (SCAA, 2015)

Attribute	Term	Definition
Color	Dark brown color	The brewing color
Aroma	Leafy	An aroma characteristic associated with leafy plants
Aroma	Sour	The impression associated with sour product
Aroma	*Roasted*	The impression associated with roasted coffee
Aroma	Spicy	The impression associated with spices aromatic
Taste	Acid/Sour	The basic taste of which acid-stimulating
Taste	Sweet	The basic taste of which sugar stimulating associated sweetness from stevia
Taste	Bitter	The basic taste of which quinine or caffeine-stimulating
Taste	Green	The taste associated with leafy plants
Taste	Spice	The taste associated with species
Aftertaste	*Over*	Exaggerated taste left on the tongue
Aftertaste	Bitter	The astringent taste left on the tongue
Aftertaste	Sweet	The sweet taste lingers on the tongue

The appearance of coffee was categorized as dark, defined as the color of brewed coffee. The color could also be translated as the color of roasted coffee (Hayakawa et al., 2010). Research conducted by Hayakawa et al. (2010) shows that the appearances with dark color descriptions were defined by consumer panelists, transparent dark, blackish-blown were defined by professional panelists, while trained panelists defined reddish-brown, orangish-brown and yellowish-brown. The intensity of sourness is related to bitterness and sweetness. The increased sour intensity and the reduction of bitter and sweet taste (Chen et al., 2023). Roasted aromatic is described as a pleasant aroma of various foods. This indicates that adding stevia did not cover the pleasant aroma of coffee. No global consensus data from consumers describes the good quality of coffee, and the stevia coffee lexicon is sometimes still influenced by culture and language. The data obtained in this research can provide information for developing coffee stevia products.

3.2. Sensory Analysis by RATA

The CATA question represents a cutting-edge approach within research methodologies that focuses on assessing distinct attributes. The inquiry comprises a series of terms or expressions from which participants must choose all those they deem suitable for delineating a commodity (Jolliffe & Cadima, 2016). Developing CATA, RATA, panelists can assess the characteristics' magnitude (Ares et al., 2014). Consequently, the mean response of stevia coffee might yield more perceivable sensory traits, facilitating the differentiation of products that exhibit significant disparities. This approach has been noted as a straightforward, reliable, and replicable substitute for acquiring insights into the sensory attributes of a diverse array of commodities. Using natural sweetening agents in coffee, like stevia, remains uncommon. Hence, examining their characteristics and potency through applying the Relative Attribute Tasting Analysis (RATA) is imperative.

Thirty panelists for sensory analysis were 60% men and 40% women, aged 15 to 60 years old. The minimum number of non-trained panelists for organoleptic analysis was 30 (BSN, 2006). Twelve panelists were women, and eighteen panelists were men. Age and gender data is required since sensory perception based on age and gender is very different (Djekic et al., 2021). Stevia robusta coffee is formulated in four-level concentrations: A1, A2, A3, and A4. All the samples were used to create the sensory profile of stevia coffee using the RATA (rate-all-that-apply). Table 2 displays the sample's attributes and variance using Friedman's analysis (Ares et al., 2014). Five sensory attributes (dark brown color, sour aromatic, roasted aromatic, spicy aromatic, and acid taste) did not produce significant differences between the formulas. This phenomenon may arise due to the utilization of panelists categorized as non-trained, which leads to varying sensory rates. Research conducted by Hayakawa et al. (2010) states that trained panelists practice more easily describing or detecting differences between sensory attributes.

Table 2 One-way analysis of variance of stevia coffee

Attribute	*p-value*
Dark brown color (brewing)	0.327
Green aromatic	0.001*
Sour aromatic	0.099
Roasted aromatic	0.471
Spicy aromatic	0.385
Acid/Sour taste	0.196
Sweet taste	0.001*
Bitter taste	0.000*
Green taste	0.000*
Spice taste	0.000*
Over aftertaste	0.000*
Bitter aftertaste	0.000*
Sweet aftertaste	0.000*

* *p-value* < 0.05

Eight of the 13 attributes, including green aromatic, sweet taste, bitter taste, green taste, spice taste, over aftertaste, bitter aftertaste, and sweet aftertaste, were shown to be significantly different between samples. Green aromatics potentially come from stevia. Stevia's leafy aromatic is moderate and pleasant, with a faint anise or licorice-like flavor (Chughtai et al., 2020). Bitter aftertaste description is probably caused by minute steviol glycosides (stevia) or caffeine (coffee), which can interact with the tongue's bitter taste receptors (Dwivedi & Tomer, 2018; World Coffee Research, 2017). The aftertaste is the last attribute evaluated. After sipping the coffee, wait 15 minutes to determine the aftertaste. Steviol glycoside exhibits a sweetness level that is 350 times higher than sucrose. Rubusoside (Rub) has demonstrated efficacy as both a solubilizer for anti-cancer medications and a sweetening agent (Wang et al., 2023). Table 3 shows the outcomes of Nemenyi's additional tests.

The 0% formula had the highest intensity of sour taste and bitterness, significantly different from other formulas. Formula, 0% stevia, had the lowest intensity of green taste, spice taste, and aftertaste. This is because there was no addition of stevia leaves. The green aftertaste could be from coffee, stevia, or both. On the other hand, the 10% formula had the highest intensity of leafy aromatic, sweet taste, green taste, spice taste, bitter aftertaste, and sweet aftertaste. International Coffee Organization (ICO) evaluated the senses of coffee, whereby nine sensory characteristics, including ashy, burnt/smoky, cereal/malty/toast, fruity/citrus, grassy/green/herbal, acidity, bitterness, body, and astringency (Hayakawa et al., 2010). Using stevia as a sweetener in other products like yogurt revealed that stevia influenced two sensory attributes: sourness and sweetness (Narayanan et al., 2014).

Table 3 Post Hoc analysis by Nemenyi of stevia coffee profile

Attribute	Sampel	The average rating
Leafy aromatic	A1	2.133a
	A2	2.200a
	A3	2.417ab
	A4	3.250b
Sweet taste	A1	1.317a
	A2	1.833a
	A3	3.150b
	A4	3.700b
Sour taste	A1	3.517b
	A2	2.900b
	A3	1.950a
	A4	1.633a
Green taste	A1	1.750a
	A2	2.383ab
	A3	2.850b
	A4	3.017b
Spice taste	A1	1.317a
	A2	2.683b
	A3	2.817b
	A4	3.183b
Over aftertaste	A1	1.650a
	A2	2.967b
	A3	2.683b
	A4	2.700b
Bitter aftertaste	A1	3.183b
	A2	2.900b
	A3	2.000a
	A4	3.750a
Sweet aftertaste	A1	1.283a
	A2	2.067ab
	A3	2.900bc
	A4	3.750c

Notes: A1: stevia 0%; A2: stevia 4%; A3: stevia 7%; and A4: stevia 10%

Rate scale: 1 = very low, 2 = slightly low, 3 = moderate, 4 = slightly high, and 5 = very high

Each sample's sensory characteristics were organized using the Principal Component Analysis (PCA) approach in a biplot graph, Figure 1. PCA can visually represent the extensive and intricate information contained within datasets via bi and tridimensional plots, such as biplots, score plots, and loading plots. The contribution of each Principal Component (PC) to the overall variance in the data is ascertained by utilizing Eigenvalues (Dobriban, 2017). Each Eigenvalue corresponds to an Eigenvector, determining the respective PCs' dispersion. According to Jollife and Cadima (2016), principal component analysis (PCA) produces a principal component, or factor (F), which is the variable that remains after all other variables are reduced to a minimum without losing the information found in the original or initial data. There were two main components; the variance for the first component was 67.28%, and the second component had a total cumulative variance of 91.81%. This value is sufficient to explain the sample variation since the minimum cumulative value is 75% (McPherson, 2001). In this study, PC1 was described by the attributes of a sweet aftertaste followed by a sweet taste, sour taste, and astringent aftertaste. Meanwhile, PC2 was represented by roasted aromatics, spice aromatics and an over-aftertaste.

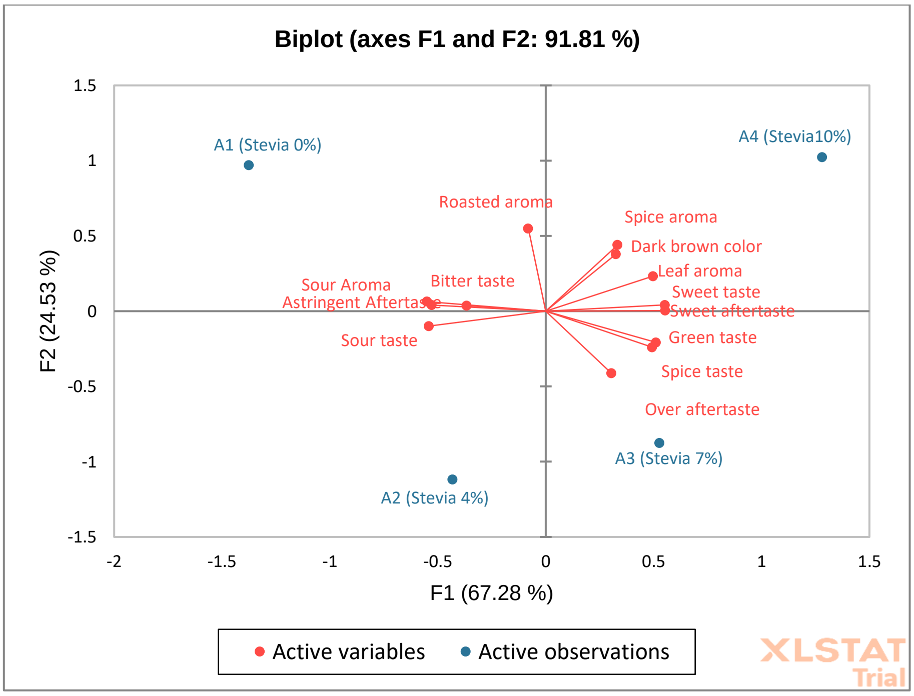

Figure 1 PCA Biplot Graph of Components F1 and F2

The attribute dots' locations on the graph display the correlation between attributes. Attribute points are substantially positively connected if they are located near each other and far from the center (r approaches 1). It indicates that other attributes come after the presence of one attribute. The attributes, on the other hand, have a significantly negative correlation (r approaching -1) if the attribute points are on different sides of the center, indicating that the existence of one characteristic is in opposition to the other. If the features of the dots are separated (Abdi & Williams, 2010). The bitterness taste dot is situated closely to the centroid of the graph, a phenomenon attributed to PCA (F1) and (F2), which inadequately elucidates these attributes.

Based on the biplot graph, sample A4 (10% stevia coffee) is in quadrant I, A1 (coffee stevia 0%) in quadrant II, A2 (coffee stevia 4%) in quadrant III, and A2 (4% stevia coffee) in quadrant IV. This data demonstrates how each sample has a sufficiently diverse sensory profile. According to Lee et al. (2013), samples in one quadrant's adjacent sample points have similar profiles, whereas samples in the other quadrant have different characteristics. The attribute points' locations on the graph display the correlation between attributes. The A4 sensory profile is represented by the aroma attribute of spices, dark brown color, leaf aroma, sweet taste, and perceived sweet aftertaste, which were significantly and positively correlated. It means that one of these attributes indicates the existence of other attributes. The attributes of astringent aftertaste, sour aromatic, roasted aromatic, and bitter taste represent sample A1. The sour taste attribute represented sample A2.

Meanwhile, the A3 sample of 7% stevia coffee was represented by the attributes of green taste, spice taste, and aftertaste. Seninde et al. (2020) characterized the aroma of robusta coffee as smoky, ashy, woody, roasted, sweet aromatic, burnt, green, nutty, fruity floral, cocoa, fermented, earthy, and stale. The intensity depends on the processing method, e.q. wet and dry process, dark or medium roast. The pleasant aroma of roasted aromatic is correlated with pyrazine compounds (2-ethylpyrazine, 2-ethyl-3,5- dimethylpyrazine, and 2-ethyl-6-methylpyrazine) (Caprioli et al., 2015). The other compounds responsible for the sensory profile of coffee are phenolic derivatives. Guaicol compounds affect spicy aromatics. Chlorogenic acids and caffeine contribute to the bitterness of coffee (Fujioka & Shibamoto, 2008; Seninde et al., 2020). Robusta coffee has heavy body characteristics, which consumers, especially Indonesian people prefer. The rounded body of Robusta Coffee is explained by its higher polysaccharide content compared to arabica coffee (Farah, 2012).

3.3. Map of panelists' Favorite Stevia-Based Coffee Items

The panelists differentiate the sample by using preference mapping. According to Martínez et al. (2002), preference mapping is a technique that connects consumer liking (hedonics) with the characteristics of a product. Preference mapping analysis produces a map of panelists' preferences for samples in graphic form contour plot. The sample is positioned in the preference map depending on the preference value above the average. Map of panelists' general preferences (Figure 2).

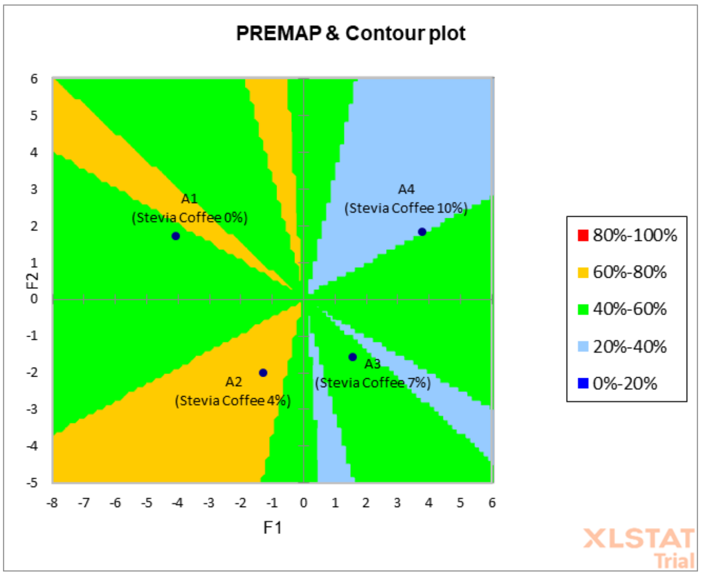

Figure 2 PREFMAP Graph and Contour Plot of Stevia Coffee

Based on the preference mapping, sample A2 (stevia 4%) was in the dark yellow area, represented by the attribute sweet and sour taste. Both attributes were best based on panelist assessment with a preference mapping of 60% -80%. In agreement with the study by Narayanan et al. (2014), stevia sweetener affected the perception of two key sensory attributes: sweet and sour taste. Samples A1 (stevia 0%) and A3 (stevia 7%) are in the green area with preliminary mapping 40%-60%; this value already shows above-average liking. Meanwhile, A4 (stevia 10%) was in the blue zone with preference mapping results of 20%-40% and represented by spice aroma, dark brown color, leafy aroma, and sweet aftertaste were less liked by panelists.

Savita et al. (2004) showed that green stevia leaf powder had a sweet intensity 350 times higher than sucrose. The sweet taste of stevia leaves comes from the stevioside compound. The sweetness intensity of stevioside needs to be lowered, making stevia less popular. Based on the distribution of contour plot color areas, the attributes that influenced the panelist's preferences for stevia coffee were sweet and sour taste. Meanwhile, the less favored attributes were the aroma and sourness, the taste of leaves and spices, and the astringent and sweet aftertaste. The less preference for aroma because stevia leaf powder has a powerful leafy aroma. In the end, the aroma of the product tends to be herbal-like. The unpleasant odor of stevia leaves comes from volatile aliphatic aldehyde compounds, 3-methylbutanal. Aftertaste arises from the oil, tannin, and flavonoid content in stevia leaves (Kusumaningrum, 2019). Research conducted by Narayanan et al. (2014) utilized stevia as a sweetener in yogurt. The results showed that the panelists disliked using 0.7% stevia in yogurt products. Comprehensive research is needed regarding adding other ingredients that can mask the flavor produced by stevia. (Samakradhamrongthai and Jannu (2021) used stevia (6%) and xylitol (6%) as sweetener and corn syrup (7.5%) as flavor agents in product candy. This combination gives a similar response by consumers. The use of xylitol provides a sweet and cooling effect when used orally.

3.4. Stevia coffee chemical characteristics

In this research, chemical analysis involves determining the water and ash content. The chemical analysis of stevia coffee is presented in Table 4.

3.4.1. Wate content

Adding stevia to coffee at various concentrations had no significant effect on water content (P>0.05), Table 4. The water content of stevia coffee ranges from 2.82% - 2.93%. This value is accepted by referring to SNI 8964:2021 (BSN, 2021), which states that the maximum water content of coffee grounds is 5%. This result agreed with (Corrêa et al., 2016) that the water content of ground coffee hovers around <3%. The granularity or fineness of the coffee impacts the water content of coffee. A finer grind results in a more excellent retention of water molecules in specific sites. Coffee displays hygroscopic properties, allowing it to absorb water molecules readily. Moreover, the water content of coffee is subject to the influence of the roasting procedure, with a higher degree of roasting leading to a higher release of water molecules.

Table 4 The average chemical analysis of stevia coffee.

Formula stevia coffee	The parameter analysis	
	Water content (%)	Ash content (%)
A1	2.83^{a}	4.05^{a}
A2	2.82^{a}	4.07^{a}
A3	2.93^{a}	4.719^{b}
A4	2.93^{a}	4.94^{c}

Notes: A1: stevia 0%; A2: stevia 4%; A3: stevia 7%; and A4: stevia 10%

3.4.2. Ash Content

Ash content is a mixture of inorganic or mineral components in a food ingredient. Food ingredients comprise 96% inorganic materials and water; the rest are mineral elements. Determining total ash content serves multiple purposes, such as assessing the quality of processing, identifying the composition of the material utilized, and evaluating the nutritional properties of a food component. It is imperative to recognize that the ash content represents the residue of an inorganic nature resulting from the incineration of organic matter. The quantity and constituents of ash are contingent upon the nature of the material and the ignition method employed (Anggarani et al., 2019). Based on the analysis results, it was found that adding several concentrations of stevia to coffee had a significant effect on the ash content (P<0.05).

Duncan's further analysis showed that the ash content of coffee A1 (0% stevia), A2 (4% stevia), and A4 (10% stevia) had no significant differences. Sample A3 (7% stevia) and A4 (10% stevia) coffees had significantly different ash contents (P<0.05). The ash content of Stevia coffee falls within the range of 4.05% to 4.94%, meeting the specifications outlined in SNI 8964:2021, which mandates a maximum limit of 6% (BSN, 2021). The mineral content in the leaf causes the increasing ash content in stevia coffee. The mineral content in stevia leaves varies, such as phosphorus, iron, potassium, calcium, sodium, and magnesium (Chandra & Novalia, 2014).

3.4.3. Antioxidants of selected product

Based on the sensory analysis, the selected sample was product A2 (4% stevia) and continued to have antioxidant activity. The antioxidant activity of coffee stevia is shown in Table 5.

Table 5 The antioxidant content of selected formula of stevia coffee (A2)

Parameter	% Inhibition
Antioxidant activity	83.13

The addition of stevia to robusta coffee increases antioxidant activity. The antioxidant contained in the selected sample (A2) was 83.13%. According to Pokorná et al. (2015), the antioxidant activity in robusta coffee is 63.2%. Coffee contains bioactive compounds, e.q. Alkaloids, phenolics, terpenoids, Maillard reaction products (MPRs). The bioactive compounds demonstrate antioxidant properties, which could potentially play a role in the mitigation of specific degenerative conditions (Herawati et al., 2019). This characteristic aligns with epidemiological research indicating the substantial impact of coffee consumption on reducing the risk of type 2 diabetes mellitus (Y. Zhang et al., 2011), as well as its potential in mitigating the onset of Parkinson's and Alzheimer's diseases and certain types of cancer (Herawati et al., 2019; Y. Zhang et al., 2011). The contribution of stevia can also cause the high antioxidant capacity content. Research has demonstrated that incorporating 0.24% stevia into chocolate items can elevate antioxidant efficacy (Kusumaningrum, 2019). The composition of bioactive compounds in coffee beans and the coffee brew is significantly influenced by processing procedures, with roasting being identified as the pivotal step (Herawati et al., 2019).

The enhanced antioxidant capacity of 4% stevia in coffee (A2) was similarly influenced by the addition of stevia. The flavonoid components in stevia foliage are antioxidants through their interaction with metal ions such as iron (Fe) and copper (Cu). These metal ions act as catalysts in various processes, generating free radicals (Kusumaningrum, 2019).

4. Conclusion

Divergences in the concentration of stevia affect the sensory attributes of each treatment involving stevia coffee. The sensory features characterizing stevia coffee from FGD encompassed a dark brown hue and leafy aroma and notes of sourness, roasting, spices, sweetness, bitterness, leafiness, and aftertastes, including astringency and sweetness. Variations in stevia concentration were shown to affect the sensory qualities of each treatment. The sensory evaluation of Sample A2, a stevia-infused coffee with 4% stevia, revealed a taste profile marked by sweetness and sourness, which resonated positively with the evaluators. Furthermore, chemical analysis unveiled that the water content of stevia coffee ranged from 2.82% to 2.93%, and the ash content spanned from 4.05% to 4.94%, aligning with the stipulations of the SNI 8964:2021 standards about coffee powder. The chosen product demonstrated an antioxidant activity level of 83.13%.

Acknowledgment

We express our gratitude to the Indonesian Industrial and Beverage Crops Research Institute (IIBCRI), Ministry of Agriculture Republic Indonesia, for supporting our research.

References

Abdi, H., & Williams, L. J. (2010). Principal component analysis. *Wiley Interdisciplinary Reviews: Computational Statistics*, *2*(4), 433–459. https://doi.org/10.1002/WICS.101

Adawiyah, D. R., Tjiptoputri, O. M., & Lince, L. (2020). Profil sensori sediaan pemanis dengan metode rate-all-that-apply (RATA). *Jurnal Mutu Pangan: Indonesian Journal of Food Quality*, *7*(1), 38–45. https://doi.org/10.29244/jmpi.2020.7.1.38

Adawiyah, D. R., & Yasa, K. I. (2017). Evaluasi profil sensori sediaan pemanis komersial menggunakan metode check-all-that-apply (CATA). *Jurnal Mutu Pangan: Indonesian Journal of Food Quality*, *4*(1), 22–29.

Anggarani, M., Ayuningsih, A., Yudianto, E., & Prasodi, B. (2019). *The composition of water and ash of secang wood's simplicia and secang wood herbal drink powder*. *1417*(1), 012033. https://doi.org/10.1088/1742-6596/1417/1/012033

Ares, G., Bruzzone, F., Vidal, L., Cadena, R. S., Giménez, A., Pineau, B., Hunter, D. C., Paisley, A. G., & Jaeger, S. R. (2014). Evaluation of a rating-based variant of check-all-that-apply questions: Rate-all-that-apply (RATA). *Food Quality and Preference*, *36*, 87–95. https://doi.org/10.1016/j.foodqual.2014.03.006

Bicho, N. C., Leitão, A. E., Ramalho, J. C., de Alvarenga, N. B., & Lidon, F. C. (2013). Identification of chemical clusters discriminators of Arabica and Robusta green coffee. *International Journal of Food Properties*, *16*(4), 895–904. https://doi.org/10.1080/10942912.2011.573114

B. S. N. (2006). *SNI 01-2346-2006 Tentang Petunjuk Pengujian Organoleptik dan atau Sensori*.

B. S. N. (2021). *SNI 8964:2021 tentang Kopi sangrai dan kopi bubuk*

Caprioli, G., Cortese, M., Sagratini, G., & Vittori, S. (2015). The influence of different types of Preparation (espresso and brew) on coffee aroma and main bioactive constituents. *International Journal of Food Sciences and Nutrition*, *66*(5), 505–513. https://doi.org/10.3109/09637486.2015.1064871

Chandra, A., & Novalia, N. (2014). Studi Awal Ekstraksi Batch Daun Stevia Rebaudiana Bertoni Dengan Variabel Jenis Pelarut Dan Temperatur. *Research Report-Engineering Science, 2*.

Chen, S., Xiao, Y., Tang, W., Jiang, F., Zhu, J., Zhou, Y., & Ye, L. (2023). Evaluation of Physicochemical Characteristics and Sensory Properties of Cold Brew Coffees Prepared Using Ultrahigh Pressure under Different Extraction Conditions. *Foods*, *12*(20), 3857. https://doi.org/10.3390/foods12203857 de Oliveira, C. C., Gotardo, É. F. M., de Souza, V. T., Rocha, T., Macedo, J. A., de Oliveira Carvalho, P., Ribeiro, M. L., & Gambero, A. (2014). Caffeinated and decaffeinated instant coffee consumption partially reverses high-fat diet-induced metabolic alterations in mice. *Food Research International*, *61*, 120–126. https://doi.org/10.1016/j.foodres.2014.02.025

Djekic, I., Lorenzo, J. M., Munekata, P. E., Gagaoua, M., & Tomasevic, I. (2021). Review on characteristics of trained sensory panels in food science. *Journal of Texture Studies*, *52*(4), 501–509. https://doi.org/10.1111/jtxs.12616

Dobriban, E. (2017). *Sharp detection in PCA under correlations: All eigenvalues matter*. https://doi.org/10.1214/16-AOS1514

Dwivedi, S., & Tomer, N. (2018). Stevia rebaudiana the unique medicinal plant with sweet taste having hypoglycemic and hypolipidemic activities. *Indian Heart Journal*, *70*(3), 458. https://doi.org/10.1016/j.ihj.2018.04.001

Farah, A. (2012). 2 Coffee Constituents. In Y.-F. Chu (Ed.), *Coffee: Emerging Health Effects and Disease Prevention* (1st ed., pp. 21–58). Blackwell Publishing Ltd. https://doi.org/10.1002/9781119949893.ch2

Fujioka, K., & Shibamoto, T. (2008). Chlorogenic acid and caffeine contents in various commercial brewed coffees. *Food Chemistry*, *106*(1), 217–221. https://doi.org/10.1016/j.foodchem.2007.05.091

Gaascht, F., Dicato, M., & Diederich, M. (2015). Coffee provides a natural multitarget pharmacopeia against the hallmarks of cancer. *Genes & Nutrition*, *10*, 1–17. https://doi.org/10.1007/s12263-015-0501-3

Hayakawa, F., Kazami, Y., Wakayama, H., Oboshi, R., Tanaka, H., Maeda, G., Hoshino, C., Iwawaki, H., & Miyabayashi, T. (2010). Sensory lexicon of brewed coffee for Japanese consumers, untrained coffee professionals and trained coffee tasters. *Journal of Sensory Studies*, *25*(6), 917–939. https://doi.org/10.1111/j.1745-459X.2010.00313.x

Herawati, D., Giriwono, P. E., Dewi, F. N. A., Kashiwagi, T., & Andarwulan, N. (2019). Critical roasting level determines bioactive content and antioxidant activity of Robusta coffee beans. *Food Science and Biotechnology*, *28*, 7–14. https://doi.org/10.1007/s10068-018-0442-x

Jahangir Chughtai, M. F., Pasha, I., Zahoor, T., Khaliq, A., Ahsan, S., Wu, Z., Nadeem, M., Mehmood, T., Amir, R. M., & Yasmin, I. (2020). Nutritional and therapeutic perspectives of Stevia rebaudiana as emerging sweetener; a way forward for sweetener industry. *CYTA-Journal of Food*, *18*(1), 164–177. https://doi.org/10.1080/19476337.2020.1721562

Jeon, J.-S., Kim, H.-T., Jeong, I.-H., Hong, S.-R., Oh, M.-S., Yoon, M.-H., Shim, J.-H., Jeong, J. H., & Abd El-Aty, A. (2019). Contents of chlorogenic acids and caffeine in various coffee-related products. *Journal of Advanced Research*, *17*, 85–94. https://doi.org/10.1016/j.jare.2019.01.002

Jolliffe, I. T., & Cadima, J. (2016). Principal component analysis: A review and recent developments. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*, *374*(2065), 20150202. https://doi.org/10.1098/rsta.2015.0202

Keefer, H., Nishku, S., Gerard, P., & Drake, M. (2020). Role of sweeteners on temporality and bar hardening of protein bars. *Journal of Dairy Science*, *103*(7), 6032–6053. https://doi.org/10.3168/jds.2019-17995

Kempf, K., Herder, C., Erlund, I., Kolb, H., Martin, S., Carstensen, M., Koenig, W., Sundvall, J., Bidel, S., & Kuha, S. (2010). Effects of coffee consumption on subclinical inflammation and other risk factors for type 2 diabetes: A clinical trial. *The American Journal of Clinical Nutrition*, *91*(4), 950–957. https://doi.org/10.3945/ajcn.2009.28548

Kim, D., Kwak, H., Lim, M., & Lee, Y. (2023). Comparison of Check-All-That-Apply (CATA), Rate-All-That-Apply (RATA), flash profile, free listing, and conventional descriptive analysis for the sensory profiling of sweet pumpkin porridge. *Foods*, *12*(19), 3556. https://doi.org/10.3390/foods12193556

Kusumaningrum, I. (2019). Pemanfaatan Sereh (Cymbopogon Citratus) Dan Stevia (Stevia Rebaudiana Bertoni) Untuk Meningkatkan Kandungan Antioksidan Produk Cokelat Yang Rendah Gula. *Jurnal Agroindustri Halal*, *5*(1), 075–084. https://doi.org/10.30997/jah.v5i1.1586

Lee, J., Kim, H. Y., & Kim, J. (2017). Coffee consumption and the risk of obesity in Korean women. *Nutrients*, *9*(12), 1340. https://doi.org/10.3390/molecules180810024

Limanto, A. (2017). Stevia, pemanis pengganti gula dari tanaman Stevia rebaudiana. *Jurnal Kedokteran Meditek*.

Martínez, C., Santa Cruz, M. J., Hough, G., & Vega, M. J. (2002). Preference mapping of cracker type biscuits. *Food Quality and Preference*, *13*(7–8), 535–544. https://doi.org/10.1016/S0950-3293(02)00087-3

McPherson, G. (2001). *Applying and interpreting statistics: A comprehensive guide*. Springer. https://doi.org/10.1007/978-1-4757-3435-5

Nakilcioğlu-Taş, E. (2018). The effects of sugar addition and degree of roast on the bioactive compounds and antioxidant activity of Turkish-style coffee brews. *Indian Journal of Pharmaceutical Education and Research*, *52*(3), 456–466. https://doi.org/10.5530/ijper.52.3.53

Narayanan, P., Chinnasamy, B., Jin, L., & Clark, S. (2014). Use of just-about-right scales and penalty analysis to determine appropriate concentrations of stevia sweeteners for vanilla yogurt. *Journal of Dairy Science*, *97*(6), 3262–3272. https://doi.org/10.3168/jds.2013-7365

Niah, R., & Baharsyah, R. N. (2018). Uji Aktivitas Antioksidan Ekstrak Etanol Kulit Buah Naga Merah Super (Hyclocereus costaricencis). *Jurnal Pharmascience*, *5*(1). https://doi.org/10.20527/jps.v5i1.5781

Panagiotou, M., & Gkatzionis, K. (2022). Lexicon development to measure emotions evoked by foods: A review. *Measurement: Food*, *7*, 100054. https://doi.org/10.1016/j.meafoo.2022.100054

Pokorná, J., Venskutonis, P., Kraujalyte, V., Kraujalis, P., Dvořák, P., Tremlová, B., Kopřiva, V., & Ošťádalová, M. (2015). Comparison of different methods of antioxidant activity evaluation of green and roast C. Arabica and C. Robusta coffee beans. *Acta Alimentaria*, *44*(3), 454–460. https://doi.org/10.1556/066.2015.44.0017

Pusat Data dan Sistem Informasi Pertanian. (2022). *Outlook Komoditas Perkebunan Kopi*. https://satudata.pertanian.go.id/assets/docs/publikasi/Buku_Outlook_Kopi_2022_compressed.pdf

Safitri, D., & Arina, N. (2022). *The Trend of Drinking Coffee Culture as Indonesian Culture*. *2*(1), 117–125.

Samakradhamrongthai, R. S., & Jannu, T. (2021). Effect of stevia, xylitol, and corn syrup in the development of velvet tamarind (Dialium indum L.) chewy candy. *Food Chemistry*, *352*, 129353. https://doi.org/10.1016/j.foodchem.2021.129353

Savita, S., Sheela, K., Sunanda, S., Shankar, A., & Ramakrishna, P. (2004). Stevia rebaudiana– A functional component for food industry. *Journal of Human Ecology*, *15*(4), 261–264. https://doi.org/10.1080/09709274.2004.11905703

SCAA. (2015). *Cupping Protocols* (Speciality). https://sca.coffee/research/protocols-best-practices

Seninde, D. R., Chambers IV, E., & Chambers, D. (2020). Determining the impact of roasting degree, coffee to water ratio and brewing method on the sensory characteristics of cold brew Ugandan coffee. *Food Research International*, *137*, 109667. https://doi.org/10.1016/j.foodres.2020.109667

Wang, Y., Xu, P., Wang, W., Jia, X., Zhu, L., & Yin, H. (2023). Oligosaccharides increased both leaf biomass and steviol glycosides content of Stevia rebaudiana. *Plant Physiology and Biochemistry*, *202*, 107937. https://doi.org/10.1016/J.PLAPHY.2023.107937

World Coffee Research. (2017). *World coffee research sensory lexicon: unabridged definitions and references*. 54. https://worldcoffeeresearch.org/media/documents/20170622_WCR_Sensory_Lexicon_2-0.pdf

Zhang, K., Cheng, J., Hong, Q., Dong, W., Chen, X., Wu, G., & Zhang, Z. (2022). Identification of changes in the volatile compounds of robusta coffee beans during drying based on HS-SPME/GC-MS and E-nose analyses with the aid of chemometrics. *Lwt*, *161*, 113317. https://doi.org/10.1016/j.lwt.2022.113317

Zhang, Y., Lee, E. T., Cowan, L. D., Fabsitz, R. R., & Howard, B. V. (2011). Coffee consumption and the incidence of type 2 diabetes in men and women with standard glucose tolerance: The Strong Heart Study. *Nutrition, Metabolism and Cardiovascular Diseases*, *21*(6), 418–423. https://doi.org/10.1016/j.numecd.2009.10.020