

Original Research Article

The Effect of Process Conditions on the Sensory Profile of AeroPress Brewed Arabica Coffee

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Abstract: The AeroPress brewing method is known to offer a good sensory taste of coffee. This study investigates the influence of process conditions on the sensory profile of Arabica coffee brewed using the AeroPress method. By evaluating five different particle sizes of the coffee grounds (extra coarse, coarse, medium, fine, very fine) and five different water temperature settings (80°C, 85°C, 90°C, 95°C, 100°C), we have identified how these variables affect sensory attributes, including aroma, body, bitterness, acidity, flavour, aftertaste, and overall impression. Our findings revealed that brewing with extra fine coffee grounds at 90°C achieved the most favourable sensory qualities, outperforming other combinations in flavour complexity and balance. This study provides valuable insights for coffee enthusiasts and professionals seeking to optimise AeroPress brewing techniques.

Keywords: AeroPress; coffee brewing; sensory profile; particle size; water temperature.

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1. Introduction

In terms of coffee bean production, Malaysia holds the 47th position worldwide, contributing to approximately 0.16% of global productivity. In comparison, leading producers such as Brazil and Vietnam contribute significantly higher shares, with Brazil alone accounting for over one-third of the global coffee output. This disparity highlights Malaysia's relatively modest role in global production. However, due to limited local production capabilities and the variable quality of coffee cherries, Malaysia relies heavily on imports to meet its coffee market demands. As a result, Malaysia imports approximately 97% of its green coffee beans, with a breakdown of 55% Arabica, 35% Robusta, and 10% Liberica coffee beans (Omar *et al.*, 2022). Despite its modest domestic production, Malaysia's coffee consumption has been on the rise, fuelled by the proliferation of speciality coffee shops,

artisanal roasters, and trendy cafés catering to diverse preferences. This growing demand for quality coffee experiences underscores Malaysia's position as a dynamic player in the global coffee market, despite its status as a net importer of coffee beans.

Manual coffee brewing methods have experienced a resurgence in popularity among coffee enthusiasts worldwide, offering a hands-on and customisable approach to coffee preparation. These methods, which include pour-over, French press, AeroPress, and cold brew, allow users to control various brewing parameters such as water temperature, grind size, brewing time, and coffee-to-water ratio, resulting in a tailored and nuanced cup of coffee. Each manual brewing technique offers unique characteristics and flavour profiles, appealing to a diverse range of preferences. Pour-over methods like Chemex and V60 emphasise clarity and brightness, while immersion methods like French press and AeroPress offer full-bodied and robust cups. Cold brew, on the other hand, delivers a smooth and refreshing coffee experience with low acidity. Technical differences in these extraction methods led to quantitative differences in extraction efficiencies and thereby produced coffees with different sensory attributes (Angeloni *et al.*, 2019). Beyond the quality of the brew, manual coffee brewing fosters a deeper connection to the coffee-making process, encouraging experimentation and exploration of different coffee origins and roasts. As a result, manual coffee brewing has become a beloved ritual for many coffee aficionados, elevating the coffee experience from mere consumption to an art form.

The AeroPress coffee maker, conceptualised and developed by Alan Adler in 2005, has swiftly gained traction among coffee enthusiasts due to its versatility, portability, and knack for delivering a robust and flavourful cup of coffee within a remarkably short time. Unlike conventional drip brewing methods, AeroPress employs a unique combination of pressure and immersion brewing techniques, which are known to extract a diverse array of flavours from coffee grounds. Previous studies on AeroPress brewing have compared this method with various other manual brewing techniques (Ormaza-Zapata *et al.*, 2019; Olechno *et al.*, 2021). These investigations have focused on parameters such as caffeine content and antioxidant activity, revealing that AeroPress brewing tends to yield coffee with moderate to high caffeine levels and notable antioxidant properties. For instance, Olechno *et al.* (2021) highlighted the efficiency of the AeroPress in preserving antioxidant compounds, while Muzykiewicz-Szymańska *et al.* (2021) demonstrated its ability to achieve a balanced extraction of caffeine. Yust *et al.* (2023) further emphasised the method's versatility in enhancing the bioactive profile of brewed coffee. Additionally, a limited number of studies

have examined the sensory attributes associated with AeroPress brewing (Sunarharum *et al.*, 2020; Barrera López & Hernández Carrión, 2023).

Arabica coffee, celebrated for its intricate flavour profile and aromatic nuances, stands as an ideal candidate for experimentation with the AeroPress method due to its bright acidity, subtle sweetness, and diverse flavour complexity. These attributes complement the AeroPress's ability to extract nuanced flavours through its pressure and immersion brewing mechanism, making it a preferred choice for creating a well-balanced and flavourful cup. Various factors, including water temperature, brewing time, grind size, and coffee-to-water ratio, wield significant influence over the sensory attributes of coffee (Cordoba *et al.*, 2020; Mestdagh *et al.*, 2017; Seninde *et al.*, 2020). While extensive research has explored the effects of brewing parameters in other manual methods, such as the pour-over and French press methods (Azizah *et al.*, 2024; Ferini *et al.*, 2021), limited studies have focused specifically on the AeroPress brewing method. This research gap presents significant opportunities for the coffee industry and academia to advance understanding of AeroPress brewing dynamics. For the industry, such insights could inform the development of optimised brewing guidelines and innovative equipment designs, enhancing consumer experience. For academia, addressing this gap offers a pathway to contribute to the broader discourse on coffee science and sensory evaluation, potentially fostering collaborations between researchers and coffee professionals. This gap is noteworthy, given the influence of parameters such as water temperature and grind size on the AeroPress brewing process. Addressing this gap, the present study aims to provide the impact of these critical variables on the sensory attributes of AeroPress-brewed coffee.

Coffee sensory attributes encompass a wide range of characteristics that can vary depending on the brewing method employed. For example, pour-over methods like V60 often highlight acidity, enhancing bright and citrusy notes, while immersion methods such as the French press emphasise body, resulting in a fuller and more textured mouthfeel. Each brewing method has its distinctive influence on the aroma, flavour, acidity, body, and overall sensory experience of the brewed coffee. Understanding how brewing methods influence coffee sensory attributes empowers enthusiasts and professionals to explore and appreciate the myriad flavours and textures coffee has to offer. By manipulating brewing parameters and conducting sensory evaluations using descriptive sensory analysis, we seek to identify optimal conditions for enhancing the aroma, flavour, acidity, body, and overall quality of AeroPress-brewed Arabica coffee. Consequently, comprehending the intricate interplay of

these parameters and their collective impact on the resultant brew is imperative for coffee connoisseurs striving to refine their brewing prowess.

2. Materials and Methods

Dark-roasted Arabica coffee beans from a local brand, Mister Coffee (Malaysia), were used to brew the coffee samples. The coffee beans were ground using a Chestnut C2 coffee grinder with 25 g capacity (Timemore, China).

2.1. Response Surface Methodology (RSM)

The RSM employed in this study utilises the Central Composite design. The crucial process conditions during brewing, namely water temperature and particle size of ground coffee beans, were investigated. The ranges of particle size and water temperature were guided by industry standards and prior research on coffee brewing. The water temperature ranges from a minimum of 80°C to a maximum value of 100°C, reflecting the range where significant flavour extraction occurs. The particle size range, from 1 to 5, represents the full spectrum from extra coarse to extra fine coffee grounds. Specifically, 1 denotes extra coarse (particle size: 5 - 3 mm), 2 represents coarse (particle size: 2 - 1 mm), 3 represents medium (particle size: 850 - 1,130 μm), 4 represents fine (particle size: 430 - 800 μm) and 5 denotes extra fine (particle size: 150 - 200 μm). Through the implementation of RSM, 9 samples were chosen as outlined in Table 1, to comprehensively explore the interaction between these variables and their impact on the sensory profile of brewed coffee.

Table 1. List of samples and the selected process conditions.

Sample	Water Temperature (°C)	Particle Size
1	80	Medium
2	85	Coarse
3	85	Fine
4	90	Extra Coarse
5	90	Medium
6	90	Extra Fine
7	95	Coarse
8	95	Fine
9	100	Medium

Analysis of variance (ANOVA) was conducted to determine the statistical significance of the results, with considered significance. Model adequacy was assessed using R-squared and adjusted R-squared values, ensuring the predictive capability of the models. Residual plots and lack-of-fit tests were used to validate the models, confirming their suitability for interpreting the experimental data.

2.2. AeroPress Brewing

An AEROBIE AeroPress equipment (see Figure 1) was utilised in the AeroPress brewing process. The brewing procedures were explained in Figure 2, which visually outlines 9 steps for clarity and reproducibility. The boiled water temperature was measured using thermometer. The hot water was poured onto the ground coffee as soon as it reached the selected water temperature.



Figure 1. Polypropylene AEROBIE AeroPress equipment with 240 mL capacity.

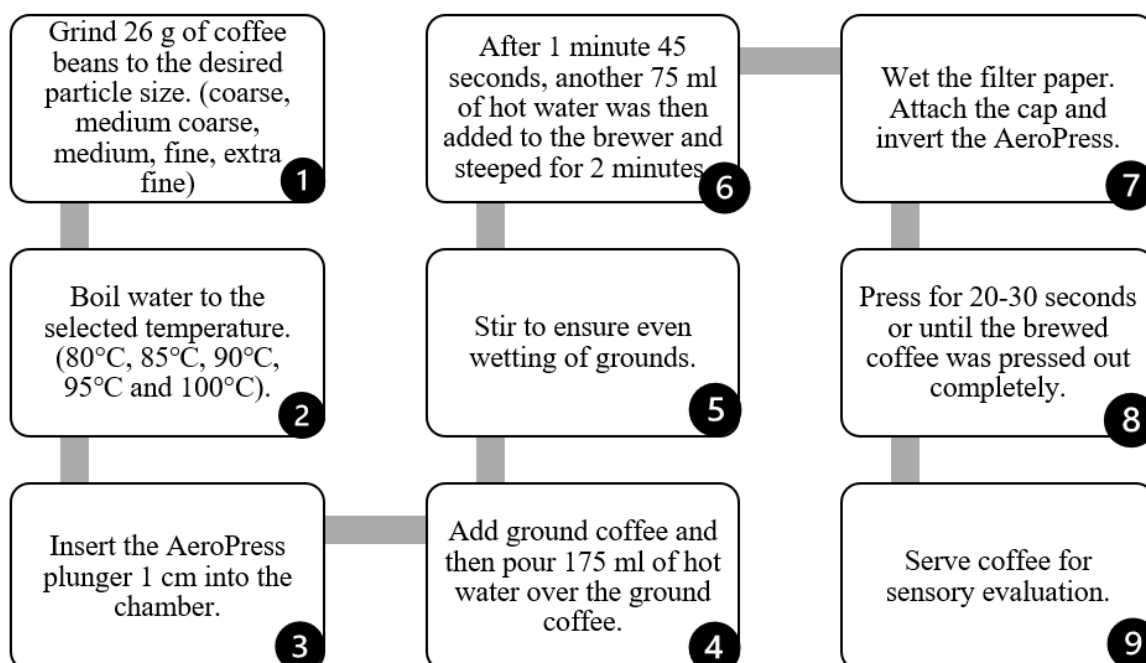


Figure 2. Flowchart of AeroPress procedures.

2.3. Sensory Evaluation

As sensory evaluators, the panellists tasted the samples of brewed coffee and evaluate the flavour and taste qualities. There are a total of 38 sensory panellists with a male-to-female ratio of 20:18, aged from 21–55 years old. The panellists were varied, from students to working people, and it covers the area of Universiti Putra Malaysia (UPM), Cyberjaya, and Nilai. The panellists were trained before evaluation sessions to ensure consistent evaluation of coffee samples. The training sessions included a familiarisation session with seven sensory attributes: aroma, body, bitterness, acidity, flavour, aftertaste, and overall impression, and practice sessions to enhance the panellists' ability to differentiate and score sensory attributes consistently. The scores evaluated by panellists were based on the 7 criteria listed in Figure 3, with a score evaluation mark of “6 = absent/ not perceivable” to “10 = intense” (Gloess *et al.*, 2013) assigned to every characteristic. These are the steps for the cup tasting: (1) the aroma-contained air was inhaled, the coffee was vigorously slurped from a spoon, and aromatics attributes were evaluated; (2) the taste attributes that were felt on the tongue were evaluated; (3) mouth feel, and overall impression was evaluated; and lastly, (4) spat out the residual coffee inside the mouth and rinsed it with water.

Sample 1 *

	Absent (Score 6)	Mild (Score 7)	Moderate (Score 8)	Strong (Score 9)	Intense (Score 10)
Aroma	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Body	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Bitterness	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Acidity	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Aftertaste	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Flavor/Taste	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Overall Impression	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Figure 3. Sensory evaluation for coffee Sample 1 at water temperature 80°C and medium particle size.

3. Results and Discussions

3.1. Sensory Evaluation of Brewed Coffee

The brewed coffee at different process conditions was evaluated based on sensory attributes of acidity, bitterness, body, flavour, aftertaste, aroma, and overall impression. Key findings related to these attributes are discussed below.

3.1.1. Body sensory attribute

The average score for the body sensory attributes is presented in Figure 4. Among the samples, Sample 4 demonstrated a mild body, receiving the lowest score compared to the others. This can be attributed to its extra coarse particle size, which limits flavour extraction despite being brewed at 90 °C. Consequently, the coffee exhibits a light or thin body characteristic.

In contrast, Sample 6, brewed at 90 °C with extra fine ground coffee, showcased a strong body sensory profile. The smaller particle size facilitates enhanced extraction of sensory notes, including smoky, nutty, roasted, and hazelnut-like flavours, consistent with findings from Caporaso *et al.* (2014). The remaining coffee samples (Sample 1, 2, 3, 5, 7, 8, and 9) achieved moderate scores ranging from 7.5 to 8.5.

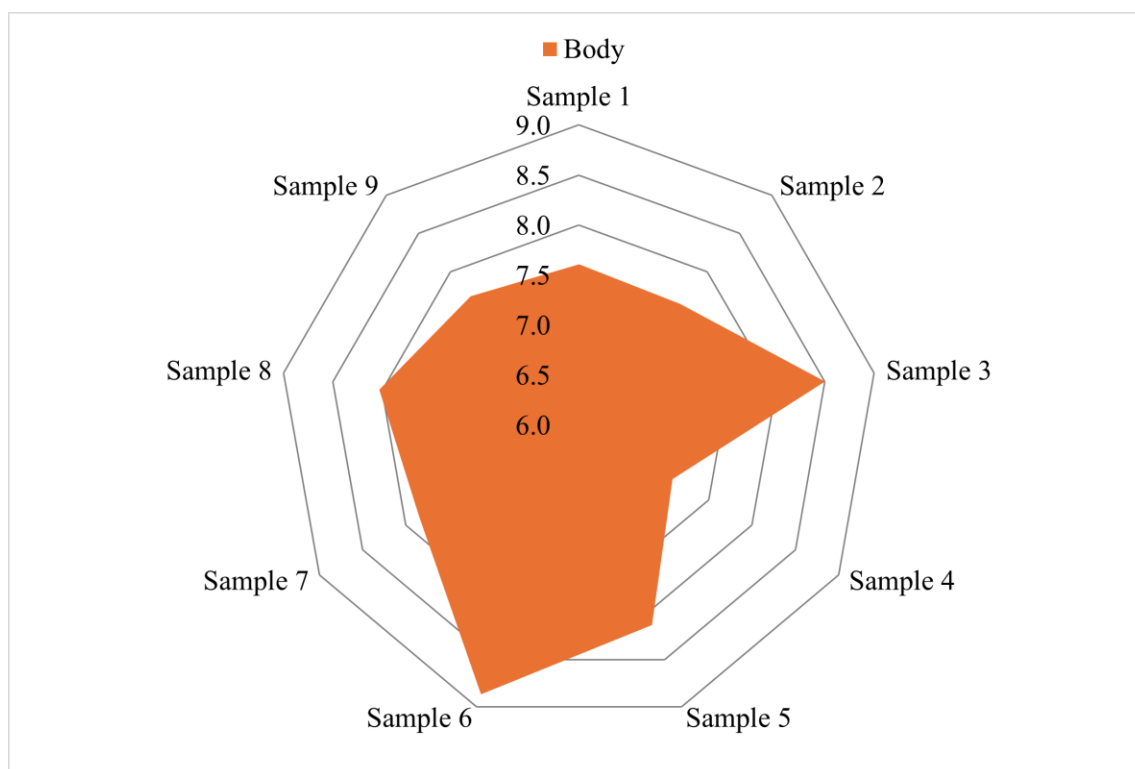


Figure 4. Average score of 'Body' sensory attributes for Sample 1–9.

Interestingly, variations in water temperature appear to influence the relationship between particle size and body perception. For instance, while particle size significantly impacts flavour extraction, deviations in water temperature can amplify or suppress these effects. This finding underscores the complex interplay between brewing parameters, emphasising the need to consider multiple factors when optimising coffee's sensory characteristics.

3.1.2. Bitterness sensory attribute

Figure 5 illustrates the average scores for the bitterness sensory attribute. A clear trend emerges: smaller particle sizes result in higher bitterness scores. This is because finer particles provide a larger surface area for extraction, intensifying flavours, including bitterness. Additionally, prolonged contact time during brewing further enhances the extraction process, contributing to the perception of bitterness.

Bitterness in the brewed coffee is significantly influenced by compounds generated during the roasting process, such as chlorogenic acid derivatives and melanoidins (Gao *et al.*, 2023). Additionally, brewing parameters, including particle size and water temperature, can affect the extraction of these key bitter compounds (Blumberg *et al.*, 2010). This highlights the interconnected roles of roasting techniques, grind size and brewing conditions in shaping the sensory profile of coffee. Thus, controlling these variables is essential for managing bitterness and achieving a balanced brew.

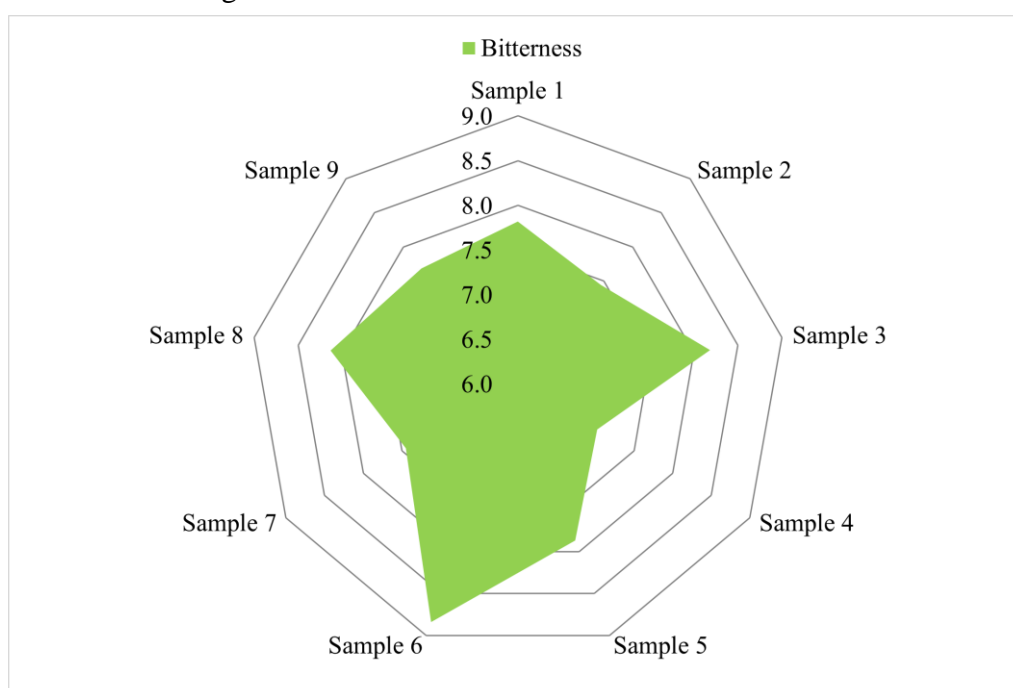


Figure 5. Average score of 'Bitterness' sensory attributes for Sample 1–9.

3.1.3. Acidity sensory attribute

The average scores for the acidity sensory attributes are presented in Figure 6. Sample 1 recorded the lowest acidity score, attributed to its lower brewing temperature compared to other samples. Rao *et al.* (2020) reported that higher water temperatures increase the availability and solubility of acidic compounds in coffee. In this study, Sample 1 was brewed at 80 °C, which limited the extraction of acidic compounds, resulting in a diminished perception of acidity relative to other samples.

Conversely, Sample 6 achieved the highest acidity score, brewed at 90 °C with extra fine ground coffee. The combination of higher temperature and finer particle size promotes the extraction of acidic compounds, enhancing their availability in the brewed coffee. This results in a bright and vibrant acidity, contributing to a well-balanced cup. However, Gloss *et al.* (2013) observed that brewing methods using paper filters tend to result in lower acidity as compared to methods without filters, as the paper absorbs fatty acids that could otherwise contribute to acidity. This suggests that the use of a paper filter in this study may have moderated the perceived acidity.

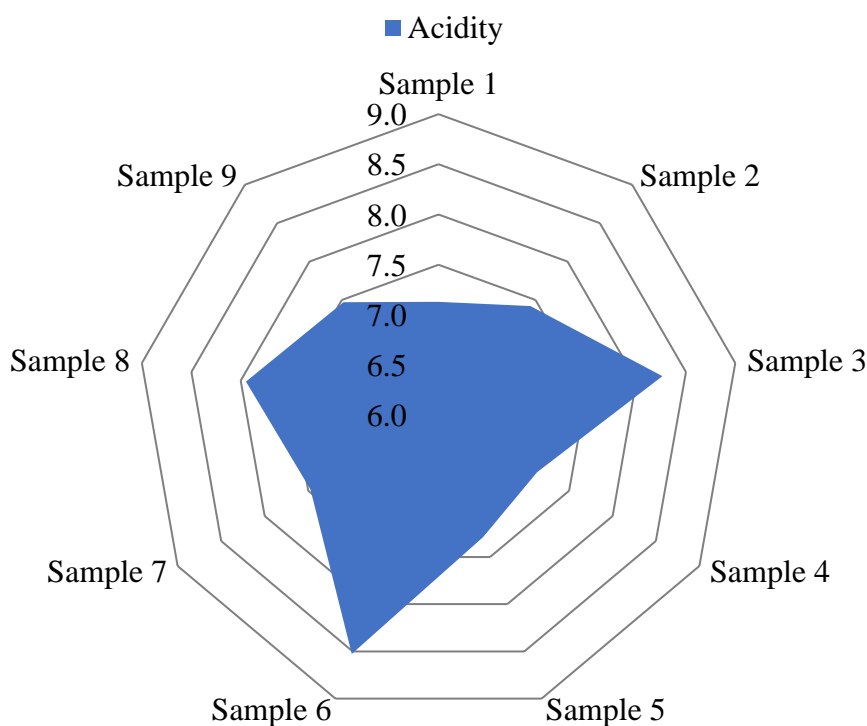


Figure 6. Average score of 'Acidity' sensory attributes for Sample 1–9.

3.1.4. Flavour/Taste sensory attribute

The average scores for flavour/taste sensory attributes are shown in Figure 7. Flavour perception is significantly influenced by the brewing process, with particle size and water temperature playing pivotal roles. Decreasing particle size intensifies strong flavours, as finer particles increase the surface area for extraction, enabling the release of more flavour compounds.

Similarly, higher water temperatures enhance flavour intensity by increasing the extraction rate, allowing for a greater variety and concentration of flavour compounds. The dynamic interplay between particle size and water temperature highlights the complexity of flavour development in coffee brewing. Factors such as origin and roasting level may further contribute to flavour variations, although these were not the focus of this study.

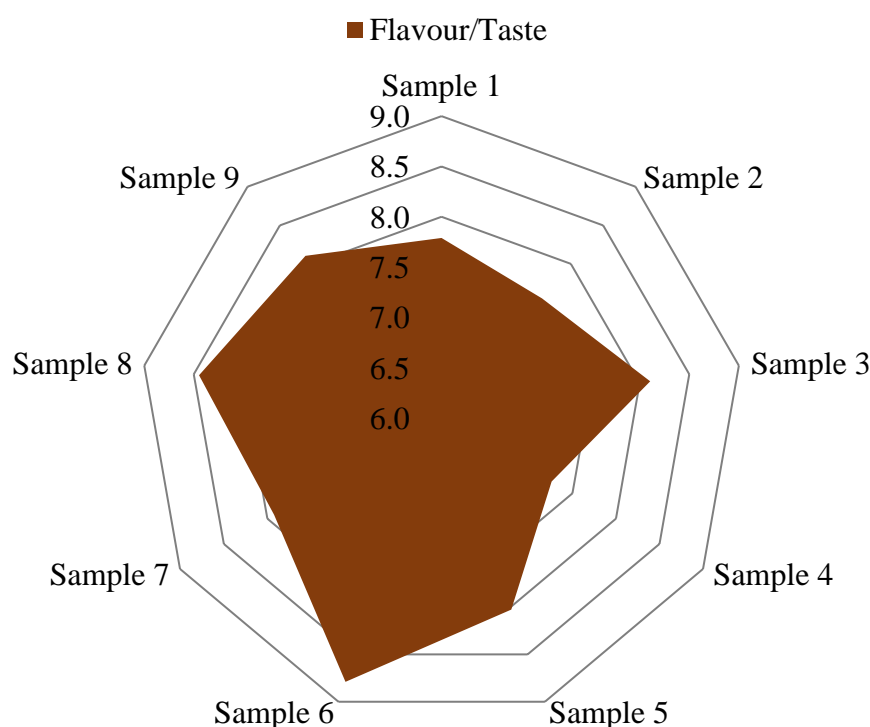


Figure 7. Average score of 'Flavour/Taste' sensory attributes for Sample 1–9.

4. Conclusions

The findings from this sensory evaluation emphasise the importance of optimising brewing parameters to achieve the desired sensory profile. While particle size and water temperature significantly influence body, bitterness, and flavour attributes, their interactions add complexity to the brewing process. From this study, it can be concluded that higher

temperatures, such as those above 90°C, and using an extra-fine ground coffee were optimal conditions for the AeroPress coffee brewing method, producing high-quality brewed coffee. Future studies could explore additional variables, such as coffee origin, post-harvest processing, and roast level, to further understand their impact on sensory outcomes.

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