

Kansei Engineering-Based Mapping of Gender Differences in Robusta Coffee Perception

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ABSTRACT

Robusta coffee is as less preferred than Arabica because of its bitterness and simple sensory profile. Nevertheless, its value is determined by consumer preferences and perceptions, which may vary according to gender. This study employed Kansei Engineering to systematically extract, quantify, and delineate gender-based perceptions of Robusta coffee into structured insights. From 160 respondents, 26 Kansei words were identified and subsequently assessed by 42 participants (21 male and 21 female) using semantic differential scales. Word cloud visualization highlighted gender-specific emphases: females focused on 'aromatic' and 'fragrant', whereas males emphasized 'comfort' and 'spirit'. These Kansei descriptors were grouped into five categories: flavor and aroma, texture and appearance, emotion and feeling, physiological effects, and additional qualities. Descriptive statistics revealed that 'aroma' and 'pleasure' achieved the highest mean scores, while 'bitter' obtained the lowest. 'Freshness' showed strong positive skewness, suggesting potential for innovation. Reliability testing confirmed high internal consistency (Cronbach's alpha > 0.80). The Mann-Whitney U test demonstrated a significant gender difference for 'aromatic'. Principal Component Analysis (KMO = 0.602; Bartlett's test, $p < 0.001$) with Varimax rotation explained 52.2% of the variance, yielding two main conceptual dimensions: affective-hedonic (44.6%), predominantly associated with females, and flavor-complexity (7.6%), more strongly associated with males, based on 18 Kansei words. MANOVA and repeated-measures ANOVA indicated no significant overall gender effect, whereas cluster analysis identified emotion-driven and flavor-oriented consumer groups. Thus, Kansei Engineering integrates sensory and emotional responses into cognitive maps, facilitating gender-based segmentation and providing practical insights for the development of Robusta coffee products.

Key words: Semantic differential; affective perception; principal component analysis; cluster analysis; consumer segmentation.

1 INTRODUCTION

Coffee is among the most widely consumed refreshment beverages, alongside cocoa and tea. Globally, three primary types of coffee are recognized: Arabica, Liberica, and Robusta. Robusta coffee contributes about 40% of global coffee production (Kath et al., 2020) and as much as 73% of coffee output in Indonesia (Indonesia Ministry of Agriculture, 2022). Although Robusta offers agronomic strengths, such as higher resistance to pests and climate variability, its market perception remains less favorable compared to Arabica (Liu et al., 2019). This lower valuation is largely attributed to its weaker sensory quality and lower complexity (Jane et al., 2020). Robusta is typically described as having a woody, muddy, robust, and bitter taste profile (Liu et al., 2019).

Flavor plays a decisive role in shaping consumer judgments. Perceptions of coffee can be classified into two dimensions: the sensory, related to flavor characteristics, and the affective, involving emotional reactions such as comfort and mood changes (Pinsuwan et al., 2022). These dimensions are interdependent and collectively influence consumer preferences, satisfaction, and loyalty. Sensory attributes may elicit positive or negative emotions, thereby affecting both acceptance and comfort.

Consumer perceptions are often determined through open-ended questionnaires to extract Kansei attributes (Kansei

words), which express perceptions, impressions, and emotional responses toward a product. These descriptors provide a linguistic bridge between sensory and emotional qualities and design specifications, thereby capturing a product's holistic image and offering a foundation for innovation aligned with consumer needs (Fatchurrohman et al., 2022). The identified Kansei words are then analyzed to determine the most relevant and significant terms, which are linked to the product's physical features.

The sensitivity of each Kansei word can be quantitatively assessed through the semantic differential method using bipolar adjective pairs, allowing for the systematic measurement of subjective experiences and the uncovering of subtle variations (Okamoto et al., 2021). Multivariate analyses, such as Principal Component Analysis (PCA) and cluster analysis, are applied to reduce dimensionality, detect dominant perceptual patterns, and segment consumers. This process translates perceptual and emotional responses into actionable design specifications that guide targeted development strategies (Vaswani, Chi & Bouwmans, 2018).

Furthermore, research indicates that gender differences affect sensory evaluation and affective experiences (Chen & Chen, 2025; Demura et al., 2013; Tifferet, Shani & Cohen, 2013). Differences are reported

in taste sensitivity, preferences, and emotional reactions between males and females when evaluating coffee attributes. Such variations are evident in taste preferences (Tifferet, Shani & Cohen, 2013), brand-related responses (Chen & Chen, 2025), and emotional experiences during coffee drinking (Pinsuwan et al., 2022).

The Kansei Engineering framework provides verbal descriptions that link sensory and emotional responses, enabling producers to translate consumer needs into product attributes (Dong et al., 2021; Ushada et al., 2023). Previous studies have applied this approach: a modified Kansei food model integrating personal attributes between expert assessors and consumer panels, identifying similarities and differences in the interpretation of sensory descriptors (Reiko et al., 2008); Kansei Engineering with logistic regression to capture sensory requirements for plain yogurt (Dolgun & Köksal, 2017); and the application of Kansei Engineering for cooking oil packaging design (Sari et al., 2023). In this research, Kansei Engineering was employed not only to collect Kansei words but also to structure them into measurable attributes (semantic differential), reduce them into perceptual constructs (PCA), and categorize them into consumer segments (clustering).

The use of Kansei words thus contributes to evaluation, development, and personalization of products based on sensory experiences, which may differ across genders. This implies that sensory attributes conveyed through Kansei could hold distinct meanings for males and females, highlighting the importance of exploring these differences in the context of Robusta coffee.

Although earlier studies have investigated gender-based coffee preferences, most have concentrated on Arabica. Limited research has specifically mapped Robusta coffee perceptions using Kansei Engineering to examine gender-related sensory differences. The present study aims to fill this gap by applying Kansei Engineering to analyze perceptions and preferences of Robusta coffee, with a focus on gender distinctions. In particular, Kansei Engineering is adopted as a methodological framework to connect affective responses (Kansei words) with development strategies.

A clear understanding of Robusta coffee consumer perceptions and preferences is essential for producers and marketers seeking to improve the product's appeal and acceptance (Gad Mohsen & Dacko, 2013; Viencz et al., 2024). This research intends to expand the literature on food science, agro-industry, and gender-based perception studies. It contributes by mapping sensory and affective aspects of Robusta coffee and providing practical guidance for segmentation and product development strategies better suited to consumer expectations.

2 MATERIAL AND METHODS

2.1 Research Design

This study employed Kansei Engineering as the primary framework, organized into three stages: 1) elicitation and categorization of Kansei words, 2) quantification using semantic differential scales, and 3) application of multivariate analysis (PCA for dimensionality reduction, MANOVA for variance analysis, and clustering for segmentation) to convert consumer perceptions into structured knowledge.

This research constitutes a preliminary exploratory study within the framework of Kansei Engineering for Robusta coffee, employing a two-phase data gathering technique. The initial phase utilized a substantial sample ($n = 160$) to generate an extensive array of Kansei words via open-ended responses. The second phase employed a more concentrated semantic differential assessment involving 42 participants. This design aligns with recognized methodologies in exploratory Kansei research, wherein PCA and perceptual structure identification are typically executed with sample sizes ranging from 30 to 50 respondents (De Winter, Dodou, & Wieringa, 2009; González et al., 2024; Mud'is et al., 2019; Sari et al., 2025). The objective of this phase is to ascertain initial perceptual dimensions rather than to produce generalizations at the population level.

2.2 Participants

A total of 160 respondents participated in the initial identification of Kansei words, and 42 respondents (21 male and 21 female) were included in the final data collection using semantic differential scales. All respondents fulfilled the inclusion criteria: regular coffee consumption at least once per week and an age range of 17–70 years. The study was approved by the Ethics Committee of Universitas Gadjah Mada (No. KE/UGM/028/EC/2023). Informed consent was obtained from all participants prior to data collection.

2.3 Coffee Consumption Context

This study did not involve a controlled sensory cupping procedure. Instead, the Kansei evaluations were based on participants' everyday experience of consuming Robusta coffee. All respondents were regular Robusta coffee drinkers from the island of Java, Indonesia: their perceptions naturally reflect the type of Robusta coffee most commonly consumed in this region: mixed local Robusta varieties that are locally produced, naturally processed, typically roasted at medium to dark levels and brewed using the *tubruk* method (an immersion technique without filtration, commonly using coffee-to-water ratios of 1:15–1:17 with water at 90–95°C), which characterises the consumption environment underlying the participants' Kansei judgements in this study.

2.4 Instrument Development

The instrument used in this study consisted of questionnaires. In the first stage, the questionnaire was administered to collect Kansei words describing Robusta coffee from 160 respondents who met the inclusion criteria. The questionnaire was distributed via Google Forms, ensuring data confidentiality and respondent anonymity. The Kansei words were then reduced in two steps: 1) grouping similar words into categories, yielding 26 representative Kansei words for coffee, and 2) constructing an affinity diagram to develop the main attributes (Kansei words for the semantic differential scale). These core attributes, expressed as Kansei words for Robusta coffee, were arranged in pairs of bipolar adjectives across seven differential scales (Table 1).

Table 1: Primary sensory attributes of Robusta coffee represented by Kansei words on a semantic differential scale (1–7).

No.	Kansei words	Negative/weak side	Positive/strong side
1	Bitter	Bitter	Sweet
2	Pleasure	Displeasure	Pleasure
3	Delicious	Unappetizing	Delicious
4	Freshness	Staleness	Freshness
5	Black	Pale	Black
6	Viscosity	Watery	Viscosity
7	Spirit	Lethargy	Spirit
8	Awake	Sleepy	Awake
9	Unique taste	Bland	Unique taste
10	Aroma	Odorless	Aroma
11	Happy	Sad	Happy
12	Fragrant	Musty	Fragrant
13	Relax	Tense	Relax
14	Adrenalin	Calm	Adrenalin
15	Acidity	Bland	Acid
16	Aromatic	Scentless	Aromatic
17	Energy	Fatigue	Energy
18	Fit	Unfit	Fit
19	Hooked	Indifferent	Hooked
20	Peace	Restlessness	Peace
21	Diuretic	Retentive	Diuretic
22	Comfort	Discomfort	Comfort
23	Thick	Thin	Thick
24	Complex	Simple	Complex
25	Steady	Unsteady	Steady
26	Moodbooster	Moodkiller	Moodbooster

2.5 Data Analysis

2.5.1 Initial perception of Robusta coffee Kansei words

The initial analysis of Robusta coffee Kansei words was performed using similarity analysis and word cloud visualization, followed by categorization of Kansei attributes with an affinity diagram.

2.5.2 Detailed quantitative perception analysis

Quantitative perception analysis was carried out through descriptive statistics, Analysis of Variance (ANOVA), and reliability testing. The non-parametric Mann–Whitney U test was applied to compare two independent groups when the assumption of normality was not satisfied. Reliability was assessed on the subsample ($n = 42$) using Cronbach's alpha, calculated separately for each gender (21 females and 21 males). According to (Peterson, 1994), a Cronbach's alpha value ≥ 0.70 indicates acceptable reliability for data use.

2.5.3 Dimensionality reduction and cognitive mapping

Kansei word extraction was validated through structural tests using the Kaiser–Meyer–Olkin (KMO) test and Bartlett's Test of Sphericity to confirm suitability for factor analysis. Principal component analysis (PCA) was applied for dimensionality reduction and to explore respondent segmentation. Multivariate analysis of variance (MANOVA) and repeated-measures ANOVA were employed to examine gender differences, with Wilks' Lambda, Pillai's Trace, and Hotelling–Lawley criteria used to determine significance across dependent variables. Agglomerative Hierarchical Clustering (AHC) and K-means clustering were further applied to construct a cognitive map based on perceptual distances and to group variables according to gender.

2.5.4 Statistical Analysis

All statistical analyses, including reliability testing, MANOVA, Repeated-Measures ANOVA, PCA, AHC, and K-means clustering, were conducted using XLStat software.

3 RESULTS

3.1 Overview of Kansei Word Extraction and Initial Perceptions

From 160 respondents, 26 Kansei words with synonymous meanings were extracted. These words varied

in frequency of mention across males and females, as well as in the combined dataset, as illustrated in the word cloud representation (Figure 1).

The 26 Kansei words obtained were classified into five main categories using an affinity diagram to structure and interpret consumer perceptions of Robusta coffee. Through this process, words with similar meanings were grouped into five principal categories: 1) flavor and aroma, 2) texture and appearance, 3) emotion and feeling, 4) physiological effects, and 5) additional qualities, as presented in Table 2.

3.2 Detailed Quantitative Analysis of Robusta Coffee Perception

Descriptive analysis was performed to provide an initial overview of consumer perceptions of Robusta coffee based on the 26 identified Kansei words (Table 3 and Table 4).

The reliability analysis for both the combined group and the male and female subgroups produced consistent results, confirming that the instrument is reliable for measuring consumer perceptions of Robusta coffee (> 0.7) (Table 5).

3.3 Dimensionality Reduction and Cognitive Mapping of Respondents

Dimensionality reduction and cognitive mapping were performed to obtain deeper insights into consumer perceptions of Robusta coffee. Principal component analysis (PCA) was used to simplify the dataset from 26 Kansei words into interpretable dimensions, validated by Bartlett's Test of

Sphericity and the Kaiser–Meyer–Olkin (KMO) measure (Li et al., 2024). The PCA mapped the semantic differential data of Robusta coffee Kansei words, with F1 accounting for 44.57% of the variance and F2 for 7.56% (Figure 2).

Based on clustering analysis using Agglomerative Hierarchical Clustering (AHC) and K-means clustering on the two factors derived from the reduced KMO values, two clusters were identified as the optimal solution. This conclusion was supported by the dendrogram results and the inertia index (total inertia 100%) with a centroid distance of 1.55, indicating a distinct separation between the clusters (Figure 3). These results are in line with the PCA findings.

4 DISCUSSIONS

The word cloud indicates that, in both separate and combined gender groups, Robusta coffee is strongly associated with Kansei words such as 'aromatic', 'spirit', 'fragrant', 'aroma', 'happy', 'pleasure', 'delicious', 'moodbooster', 'comfort', 'steady', and 'peace'. This demonstrates that for both males and females, the experience of consuming Robusta coffee is closely tied to sensory impressions, particularly aroma, and the enhancement of positive emotions. This findings consistent with the work of (Souza, Rodrigues & Sousa, 2022), who reported that coffee consumption is directly linked to an increase in positive emotional states. However, female respondents gave relatively higher ratings to the Kansei word "unique taste," indicating a potential proclivity to recognize or appreciate distinctive flavor characteristics. This pattern,

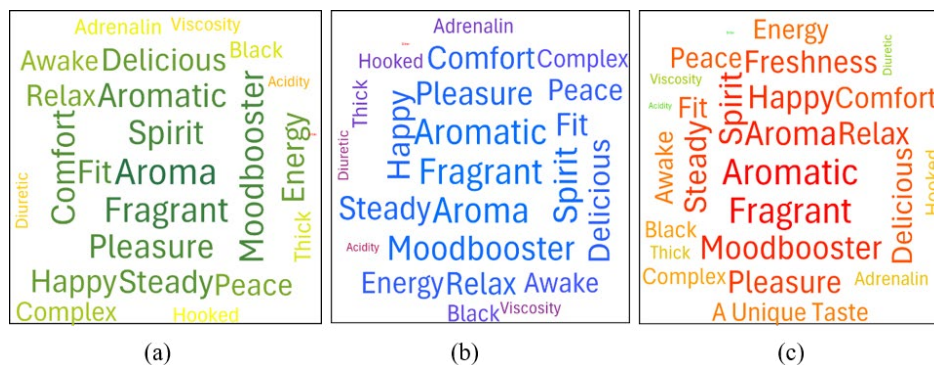


Figure 1: Word cloud showing coffee-related terms generated by male respondents (a), female respondents (b), and combined male and female respondents (c).

Table 2: Grouping of 26 Kansei words into five main categories using an affinity diagram.

No.	Main Kansei words	Descriptions
1	Flavor and Aroma	Bitter, Delicious, Unique Taste, Aroma, Fragrant, Aromatic
2	Texture and Appearance	Viscosity, Thick, Complex, Black, Freshness
3	Emotion and Feeling	Pleasure, Happy, Moodbooster, Spirit, Energy, Fit, Awake
4	Physiological Effects	Relax, Comfort, Peace, Adrenalin, Hooked
5	Additional Qualities	Steady, Diuretic, Acidity

however, should be considered as a preliminary indication rather than a conclusive gender difference, especially given the study's exploratory approach. This observation is supported by (Sollai, Solari & Crnjar, 2024), who found that women are generally more accurate in detecting and evaluating the intensity of coffee, both in simple and complex flavor compounds, and tend to show stronger preferences for aroma.

Table 3: Mean scores of 26 Kansei words for Robusta coffee.

Kansei words	Mean $\pm$ SD		
	Combined female and male	Female	Male
Bitter	3.12 $\pm$ 1.23	3.00 $\pm$ 1.39	2.90 $\pm$ 1.04
Pleasure	5.86 $\pm$ 0.87	5.90 $\pm$ 0.77	5.81 $\pm$ 0.98
Delicious	5.67 $\pm$ 0.93	5.71 $\pm$ 0.96	5.62 $\pm$ 0.92
Freshness	5.64 $\pm$ 1.06	5.90 $\pm$ 0.54	5.38 $\pm$ 1.36
Black	4.95 $\pm$ 1.55	5.14 $\pm$ 1.65	4.76 $\pm$ 1.45
Viscosity	4.31 $\pm$ 1.18	4.29 $\pm$ 1.23	4.33 $\pm$ 1.15
Spirit	5.98 $\pm$ 0.78	6.10 $\pm$ 0.62	5.86 $\pm$ 0.91
Awake	5.36 $\pm$ 1.12	5.43 $\pm$ 1.21	5.29 $\pm$ 1.06
Unique-taste	5.40 $\pm$ 1.11	5.38 $\pm$ 1.16	5.4 $\pm$ 1.08
Aroma	6.12 $\pm$ 0.83	6.14 $\pm$ 0.79	6.10 $\pm$ 0.89
Happy	5.81 $\pm$ 1.11	6.00 $\pm$ 1.05	5.62 $\pm$ 1.16
Fragrant	6.14 $\pm$ 0.72	6.33 $\pm$ 0.66	5.95 $\pm$ 0.74
Relax	5.71 $\pm$ 0.92	5.95 $\pm$ 0.86	5.48 $\pm$ 0.93
Adrenalin	4.69 $\pm$ 1.33	4.76 $\pm$ 1.37	4.62 $\pm$ 1.32
Acidity	3.88 $\pm$ 1.29	3.76 $\pm$ 1.26	4.00 $\pm$ 1.34
Aromatic	6.10 $\pm$ 0.79	6.38 $\pm$ 0.59	5.81 $\pm$ 0.87
Energy	5.57 $\pm$ 0.89	5.52 $\pm$ 0.98	5.62 $\pm$ 0.80
Fit	5.74 $\pm$ 0.96	5.71 $\pm$ 1.01	5.76 $\pm$ 0.94
Hooked	4.69 $\pm$ 1.12	4.86 $\pm$ 1.06	4.52 $\pm$ 1.17
Peace	5.57 $\pm$ 0.94	5.67 $\pm$ 0.91	5.48 $\pm$ 0.98
Diuretic	4.17 $\pm$ 1.40	4.14 $\pm$ 1.42	4.19 $\pm$ 1.40
Comfort	5.76 $\pm$ 1.01	5.76 $\pm$ 0.94	5.76 $\pm$ 1.09
Thick	4.74 $\pm$ 1.06	4.71 $\pm$ 1.06	4.76 $\pm$ 1.09
Complex	5.12 $\pm$ 1.25	5.10 $\pm$ 1.41	5.14 $\pm$ 1.11
Steady	5.83 $\pm$ 0.82	5.95 $\pm$ 0.92	5.71 $\pm$ 0.72
Moodbooster	5.98 $\pm$ 0.98	6.10 $\pm$ 1.00	5.86 $\pm$ 0.96

*Note: SD = standard deviation.

The five primary Kansei groupings (Table 2), derived from the affinity diagram, provide a structured foundation for understanding consumer perceptions of Robusta coffee and align with previous findings. Research by (Mahmud, Shellie, & Keast, 2020; Pinsuwan et al., 2022) suggests that aroma and flavor are critical predictors of coffee acceptance, significantly influencing purchasing behavior and satisfaction. The category of texture and appearance, represented by five Kansei words,

reflects the role of mouthfeel, boldness, and visual impression in sensory judgment, also emphasized by (Mahmud, Shellie, & Keast, 2020). Meanwhile, the groupings of emotion-feeling and physiological effects highlight links with positive emotions. According to (Nawrot et al., 2003; Nehlig, Daval & Debry, 1992), these effects are closely connected to the physiological impact of caffeine, which enhances mood and alertness following coffee intake.

Table 3 and Table 4 illustrates the overall consumer perception of Robusta coffee for both genders, highlighting key strengths as well as areas requiring improvement. The Kansei words 'pleasure' and 'aroma' achieved the highest mean scores (5.86 and 6.12, respectively), confirming that Robusta coffee is highly valued for its enjoyable experience and strong aromatic character. Aroma, in particular, plays a decisive role in shaping satisfaction, making it a central focus for marketing and product development. The Kansei word 'freshness', with a mean of 5.64 and strong negative skewness (-2.04), suggests that when this quality is perceived, it is highly appreciated. As such, freshness should be preserved as a unique selling point. In addition, the Kansei word 'moodbooster' (mean = 5.98) underscores Robusta's ability to elevate mood and deliver positive emotional effects.

Conversely, the Kansei word 'diuretic', which displayed high perceptual variation, emphasizes the need for clearer communication regarding the health implications of coffee consumption. Although moderate intake does not lead to dehydration in habitual drinkers, public perception remains inconsistent. Evidence suggests that moderate coffee consumption (about 3–4 cups per day) is more commonly linked with health benefits than risks (Barrea et al., 2023).

Gender differences in perception were evident, although 'aroma' and 'pleasure' emerged as significant positive attributes for both groups. Female respondents scored higher for 'aroma' (6.14) and 'fragrant' (6.33) compared to males (6.10 and 5.95, respectively), indicating greater importance placed on aromatic qualities. Females also highlighted the mood-enhancing effects of Robusta coffee, reflected in high mean values for 'moodbooster' and 'spirit'. While males acknowledged these emotional associations, they placed more emphasis on stimulant-related effects, such as 'adrenalin' (mean = 4.62).

Bitterness appeared as a key differentiating factor between genders. With the lowest mean score across all Kansei words, 'bitter' was generally less appreciated, though male respondents were slightly more tolerant of bitterness and acidity, as suggested by their higher average ratings. This distinction implies that refining post-harvest or processing methods to reduce bitterness could improve Robusta's sensory appeal, particularly for female consumers, by fostering a smoother, more balanced bitter-sweet profile.

Table 4: Skewness dan kurtosis scores of 26 Kansei words for Robusta coffee.

Kansei words	Skewness			Kurtosis		
	Combined female and male	Female	Male	Combined female and male	Female	Male
Bitter	0.75	0.69	0.50	-0.21	-0.79	-0.06
Pleasure	1.10	-1.29	-0.99	2.05	2.56	1.96
Delicious	-0.04	-0.12	0.04	-0.86	-0.86	-0.72
Freshness	-2.10	-0.11	-1.57	8.20	0.94	4.49
Black	-0.83	-1.50	-0.09	0.46	2.25	-0.73
Viscosity	-0.27	-0.25	-0.30	-0.76	-0.60	-0.84
Spirit	0.04	-0.06	0.31	-1.33	-0.11	-1.80
Awake	0.10	-0.00	0.21	-1.37	-1.59	-1.12
Unique-taste	-0.09	0.00	-0.20	-0.93	-1.50	-0.06
Aroma	-0.50	-0.27	-0.67	-0.65	-1.31	-0.22
Happy	-0.50	-0.57	-0.43	-0.62	-0.94	-0.39
Fragrant	-0.22	-0.47	0.08	-0.98	-0.55	-1.04
Relax	-0.38	-0.42	-0.34	0.41	-0.38	1.47
Adrenalin	-0.30	0.09	-0.79	-0.45	-1.35	0.58
Acidity	-0.12	-0.33	-0.00	-0.82	-0.34	-1.26
Aromatic	-0.49	-0.30	-0.10	-0.33	-0.61	-0.74
Energy	-0.12	-0.25	0.21	-0.61	-0.83	-0.41
Fit	-0.12	-0.33	0.13	-0.99	-0.82	-1.23
Hooked	0.32	0.31	0.46	0.48	0.31	1.11
Peace	-0.12	-0.11	0.10	-0.79	-0.63	-0.87
Diuretic	-0.37	-0.16	-0.61	-0.48	-1.07	0.40
Comfort	-0.54	-1.05	-0.24	-0.03	2.42	-1.25
Thick	-0.73	-0.77	-0.75	0.39	0.74	0.49
Complex	-0.31	-0.30	-0.31	-0.64	-0.92	-0.18
Steady	-0.22	-0.75	0.50	-0.47	0.13	-0.80
Moodbooster	-0.45	-0.88	-0.06	-0.94	-0.14	-1.30

Table 5: Cronbach's alpha and standardized Cronbach's alpha values for combined and separate groups.

Groups	Cronbach's α	Standardized Cronbach's α	Std. Deviation
Combined	0.86	0.89	13.01
Female	0.80	0.84	11.39
Male	0.89	0.91	14.41

Other Kansei words further reinforce these gender-related nuances. Female respondents associated 'aroma' and 'pleasure' with strong positive impressions, as reflected in negative skewness, whereas terms such as 'relax' and 'happy' exhibited relatively flat kurtosis, pointing to greater variability in emotional responses. Overall, these findings emphasize the need for segmented marketing and product strategies tailored to the sensory and emotional expectations

of different consumer groups, with particular attention to gender distinctions.

Cronbach's α and standardized Cronbach's α values for both combined and gender-separated groups (male and female) were all above 0.7, indicating good internal consistency and reliability of the instrument (Table 5). Based on the Mann–Whitney U test, among the 26 semantic differential attributes used to evaluate Robusta coffee, only the Kansei word 'aromatic' showed a statistically significant difference between male and female respondents ($p = 0.03 < 0.05$). The remaining Kansei words did not exhibit significant differences ($p > 0.05$). This result may be attributed to the greater olfactory sensitivity of female respondents toward aromatic nuances such as floral, fruity, smoky, and woody notes compared to males. This finding aligns with studies by (Chen & Chen, 2025; Tifferet, Shani & Cohen, 2013), which suggest that olfactory receptor

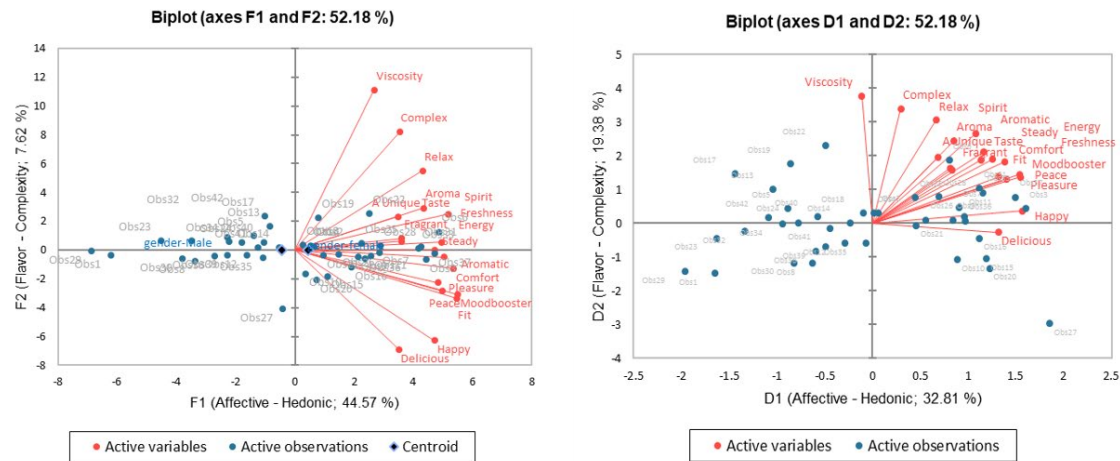


Figure 2: PCA results from 18 Robusta Kansei words before (a) and after applying Varimax rotation (b).

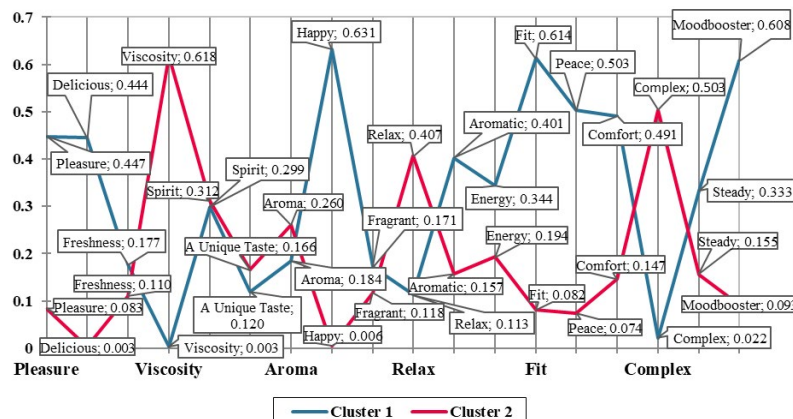


Figure 3: Results of clustering analysis using K-means clustering.

function and preference can be influenced by gender, hormones, and cultural factors. Overall, the results indicate that the main perceptual difference between male and female consumers is not in taste but in aroma.

Dimensionality reduction and cognitive mapping were performed to obtain deeper insights into consumer perceptions of Robusta coffee. PCA was applied to reduce the complexity of the 26 Kansei words into more interpretable dimensions (Li et al., 2024). Bartlett's Test of Sphericity ($p < 0.05$) confirmed significant correlations among variables (Robusta coffee Kansei words and gender), validating the use of PCA. Based on the Kaiser–Meyer–Olkin (KMO) measure, only 18 Kansei words were retained (pleasure, delicious, freshness, viscosity, spirit, unique taste, aroma, happy, fragrant, relax, aromatic, energy, fit, peace, comfort, complex, steady, and moodbooster), as their KMO values exceeded 0.5, with an average KMO of 0.60. Further PCA extraction with these 18 words yielded an improved average KMO of 0.76 (classified as mediocre) and a Bartlett's test of $p < 0.05$, confirming suitability for dimensionality reduction.

The PC1–PC2 biplot (Figure 2) indicates directional, but not categorical tendencies in the perceptual space that the centroid for female respondents shifts to the right (positive F1), while that for male respondents moves slightly upward (positive F2). This pattern suggests that, within this exploratory samples, female may exhibit a subtle inclination toward on affective-hedonic impressions (delicious, happy, pleasure, comfort, etc.), whereas males may show a modest tendency toward attributes related to texture and flavor complexity (viscosity, complex, relax, aroma, unique taste, etc.). However, because the univariate comparisons were not statistically significant and PCA explains a moderate proportion of total the variance, these patterns should be interpreted as preliminary tendencies rather than definitive gender-based differences. Research by (Sollai, Solari & Crnjar, 2024) reported that female respondents generally give higher ratings to affective aspects compared to males, while (Wahyuddin, Setyawan & Nugroho, 2017) emphasized the critical role of hedonic attributes in product desirability among female.

Since F1 included multiple loadings ≥ 0.50 , and F2 had only one significant loading in the unrotated solution, varimax rotation was applied to improve interpretability. The rotated

components, labeled D1 and D2, explained a total of 52.18% of the variance. D1, reflecting affective-hedonic, comprised 12 Kansei words (pleasure, delicious, freshness, happy, fragrant, aromatic, energy, fit, peace, comfort, steady, moodbooster). D2, representing flavor-complexity, was represented by six Kansei words (viscosity, spirit, unique taste, aroma, relax, complex).

While this rotated map provides a clearer visualization of the main perceptual dimensions, these component patterns may offer preliminary insights for potential market segmentation, though further validation is required before translating them into definitive product design recommendations. Many practical implications regarding gender segmentation should be regarded as tentative and exploratory. Further research with larger more diverse samples is needed before translating these exploratory patterns into product design recommendations.

The two rotated components capture the main perceptual qualities, but the explained variance of 52.18% indicates that considerable perceptual variability remains outside this two-dimensional structure. The patterns observed in this exploratory sample are therefore preliminary and may not generalize to all Robusta coffee consumers. Such limitations are expected in exploratory Kansei studies, given that consumer experiences with Robusta coffee vary widely according to origin, roast level, brewing practices, and individual preferences. Thus, the rotated solution should be viewed as an initial representation of the dominant Kansei dimensions rather than a comprehensive perceptual model. Future studies may examine additional components or apply alternative approaches, such as Exploratory Factor Analysis (EFA), to capture greater shared variance and refine these early insights. Gender differences in the perception of Robusta coffee were limited to a small subset of Kansei words, particularly 'aromatic' (univariate analysis, $p < 0.05$). However, this does not suggest broader differences in the overall sensory perception profile, as confirmed by MANOVA results using Wilks' Lambda, Pillai's Trace, and Hotelling-Lawley criteria ($p = 0.479 > 0.05$).

Repeated-measures ANOVA was further applied to test whether gender influenced the perception of the 18 Kansei words. The within-subjects test with Greenhouse-Geisser correction revealed significant differences among the Kansei words themselves ($F = 13.46$, $p < 0.0001$, $\epsilon = 0.58$). However, gender did not significantly affect the pattern of these differences ($F = 0.857$, $p = 0.627$), indicating that overall consumer perception patterns were consistent across both groups.

Cluster analysis (Figure 3) identified two distinct consumer segments. The first cluster was characterized by high scores on affective words such as 'pleasure', 'happy', 'fit', and 'moodbooster', representing emotional and sensory enjoyment. The second cluster was dominated by words such as 'viscosity', 'relax', and 'complex', reflecting preferences for texture and flavor complexity. These findings are consistent with the PCA results discussed earlier.

The results of this study are in line with previous work by (Gadilkar, 2024; Sollai, Solari & Crnjar, 2024), which emphasize that aroma and emotion are central to consumer product experiences. In addition, research by (Bressani et al., 2021; Chen & Chen, 2025) highlights the importance of flavor complexity in coffee product development. These findings suggest that marketing strategies and product innovation should incorporate segmentation based on emotional preferences, while also ensuring a balance of sensory attributes to meet the needs of different consumer groups.

5 CONCLUSIONS

This exploratory study showed that Kansei Engineering could map gender-related patterns in Robusta coffee perception. Aroma and pleasure emerged as the most prominent attributes in both groups. Female respondents tended to emphasise affective-hedonic impressions, whereas male respondents placed slightly greater emphasis on flavor complexity. Cluster analysis also suggested two broad consumer tendencies, namely emotion-driven and flavor-driven. These findings offer an initial picture of gender differences and should be confirmed in larger studies.

6 AUTHORS' CONTRIBUTIONS:

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7 DATA AVAILABILITY STATEMENT

Data available upon request to authors

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