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Sensory Profiling of Indonesian White Tea Using Quantitative Descriptive Analysis

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ABSTRACT

Silver needle is a common type of white tea in Indonesia. The silver needle is produced from unbloomed pekoe, is pointed, slightly hairy, and silver in color. Quantitative descriptive analysis is a sensory evaluation method that relies on trained panelists' abilities in the experiment. The purpose of this study is to create a sensory profile of white tea from Indonesia using the QDA method. Five tea samples registered to the Indonesian National Agency for Drug and Food Control (Brand Gamboeng, Ennie 1, and Cap Pucuk from the West Java, Teh Dandang from Central Java, and Brand Heizl from East Java) were evaluated by trained panelists with extensive experience who had passed selection and training processes. Water was used as the neutralizer and crackers as the carrier. Three grams of each sample were brewed at 98°C with 150 mL of water for 7 min. Each panelist described the attribute, determined the reference, and evaluated all samples on a 15-cm scale. The results of the focus group discussion has obtained 12 lexicon sensory attributes, namely: yellow-brown, burned aroma, floral aroma, dry aroma, woody aroma, green aroma, burned flavor, green flavor, fermented flavor, floral flavor, bitter taste, astringent aftertaste, and bitter aftertaste. The results also showed that the "Heizl" white tea had the following sensory characteristics: yellow-brown, burned aroma, burned flavor, fermented flavor, bitter taste, bitter aftertaste, and astringent aftertaste. Moreover, the "Dandang" white tea had the following attributes: dry aroma, floral aroma, woody aroma, green aroma, green flavor, and floral flavor.

Keywords: *Indonesian white tea, lexicon, QDA, trained panelists*

INTRODUCTION

Indonesia is one of the biggest tea producers in the world. In 2020, Indonesia could produce 138,323 tons of tea, which would make it the eighth largest tea producer in the world (FAO, 2020). Tea is one of the favorite beverages of Indonesians and is produced from the *Camellia sinensis* L plant. There are four types of tea based on the processing method (black tea, oolong tea, green tea, and white tea). Oolong tea is only semi-enzymatically oxidized, whereas black tea is completely enzymatically oxidized. Then, green and white tea are not oxidized enzymatically (Rohdiana, 2015).

During the enzymatic oxidation process, the polyphenols in tea would be degraded to catechin. The degradation of polyphenols will produce theaflavin and thearubigin compounds, responsible for steeping tea's color and taste. Therefore, each tea has a different catechin content, taste, and color.

White tea is considered a premium tea because it has a minimum processing method and uses pekoe, pekoe + 1 young leaf, pekoe + 2 young leaves, and pekoe + 3 young tea leaves, which contain many antioxidants. Several types of white tea include Flower White Pekoe, Silver Needles, Noble Beauty, White Peony, and White Darjeeling (Rayati and Widayat, 2009). However, Silver Needle is a comercial type of white tea in Indonesia, and White Peony is not produced too much in Indonesia. Silver Needle is produced from unbloomed pekoe and is pointed, slightly hairy, and silver in color. The process is minimal and uses young leaves; as a result, the polyphenol content in white tea is higher than in other types of tea. As a result, epigallocatechin gallate (EGCG) in white tea may have antioxidant effects on the body (Damiani *et al.,* 2014), antibacterial (Tomaszewska *et al.,* 2015), and anti-cancer (Hajiaghaalipour *et al.,* 2015). However, further research still needs to be carried out to determine the potential of EGCG in

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preventing disease and the dosage used by the body (Dias *et al.,* 2013).

Quantitative descriptive analysis is one of the sensory evaluation methods that rely on the abilities of trained panelists based on their experiment. Using QDA, which has ten sensory attributes (burnt smell, floral smell, dry smell, burned taste, green taste, fermented taste, floral taste, bitterness, umami, and astringent aftertaste), it was possible to describe green tea's sensory profile (Adawiyah *et al.,* 2019). Previous research found that white tea from China and Africa was sensory tested using the scoring and hedonic methods (Castiglioni *et al.,* 2015; Zhang *et al.,* 2017), while white tea from China and Spain was tested using the QDA method (Pérez-Burillo *et al.,* 2018; Li *et al.,* 2020; Ni *et al.,* 2020; Fan *et al.,* 2021). Currently, there is no sensory-based standard for white tea products; therefore, this research can be used as a guide for the public to identify high-quality white tea products and as a guide for the future development of ready-to-drink white tea products. The purpose of this study is to create a sensory profile of white tea from Indonesia using the QDA method.

MATERIALS AND METHOD

Materials

There were five samples: the Gamboeng brand from the Tea and Quinine Research Center, originating from Bandung Regency, West Java Province; the Ennie brand purchased from a supermarket in Bandung City, West Java Province; the Cap Shoot brand purchased via e-commerce, originating from Cianjur City, West Java Province; the Heizl brand from the city of Surabaya, East Java Province, through e-commerce; and the Dandang Tea brand from Batang City, Central Java Province, through an online shop. The sample used has a distribution permit from the Indonesian Food and Drug Authority. In addition to the test sample, there were crackers to carry the sample and mineral water to make the sample neutral.

Panelists'

This research was approved for human subjects from LPPM IPB University, Bogor, Indonesia, 655/IT3.KEPMSM-IPB/SK2022. A panel of eight members (all women) from the Department of Food Science and Technology at IPB University participated in this study. They have passed the selection and training processes and have experience in QDA for a minimum of 120 h until they can identify the attributes using the 15-ruler scale. The panelists joined the sensory evaluation (focus group discussion and the tests). Panelists had been trained following ISO 8586: 2012 as prepared in Table 1, while they evaluated white tea according to the sensory attributes in Table 2.

The brewing of tea

A 3 g of dry white tea leaves were weighed, then brewed in 150 mL of hot water at 98°C for 7 min. After that, tea was poured into the teapot. From the tea pot, the tea is then poured into a plastic cup with a volume of 20 mL, which has been coded with a three-digit random number. Then the tea was served to the panelists at 70°C.

Data processing

The results of the focus group discussion are displayed in the form of a sensory wheel as a sensory lexicon, which is processed using XLSTAT. The results of the QDA analysis are displayed in a spider web graph so that the attribute pattern of white tea can be seen. In addition, it is also displayed in PCA form, obtained from XLSTAT 2021. Therefore, a perceptual map is obtained that shows the sensory profile in the form of attributes and samples that are presented in the form of a biplot graph.

RESULTS AND DISCUSSION

Panel performance

Figure 1 shows the performance of the panelists in the triangular differentiation and basic aroma tests. In the triangular test, all panelists could distinguish the samples given. However, in the basic aroma test, three panelists correctly answered all questions, and three panelists incorrectly answered one question. Two panelists only answered eight of the ten samples given. In addition, a threshold test was also carried out to see the panelist's ability to detect the sample with the lowest concentration. In Figure 2, it can be seen that the six panelists were in a condition capable of detecting the lowest group concentration (the Best Estimate Threshold Group). However, there are two panelists who are above the BET Group score.

Processing of panelist selection results using the XLStat program with panel analysis features. As can be seen in Table 1, all panelists had a p-value of less than 0.05, meaning that all panelists used in the experiment had good levels of reproducibility, discriminating ability, anger, and consensus. According to Djekic *et al*. (2021), panelist selection is based on a p-value of less than or equal to 0.05. Conversely, if the p-value is higher than 0.05, the panelists will be crossed out. According to ISO 11132:2012, panel performance can be measured in three ways: the ability to discriminate, the agreement of assessments, and the ability to repeat. In addition, coupled with reproducibility, discriminating ability is the panelist's ability to distinguish between two samples that have an insignificant level of difference. Agreement is the

panelist's ability to assign a value to a product that reveals a difference. The ability to demand helps determine the stability of the panelists' judgment in assigning value to the same product, and reproducibility is the panelist's ability to provide an assessment that is in accordance with the consensus or average value of the sensory panel as a group. Performance appraisal includes an analysis of up to two of the following principles: reproducibility, repeatability, discriminatory ability, and homogeneity panels. To process panel data performance, use the XLSTAT application with the panel tools analysis feature (Djekic *et al*., 2021).

Table 1. Panel performance

Panelist	*p*-Value	Descriptor
Panelist 1	0.000	Sweet: Sucrose 1%
		Acid: Citric Acid 0,03%
Panelist 2	0.000	Bitter: Caffeine 0,03%
		Umami: Monosodium
Panelist 3	0.000	Glutamate 0,6 g/L
		Astringent: Oolong Tea
Panelist 4	0.000	*Aroma Woody
		*Aroma Dry
Panelist 5	0.000	*Aroma Green
		*Aroma Floral
Panelist 6	0.000	*Tea Aroma
		*The descriptor tea aromas
Panelist 7	0.000	from the flavour house
Panelist 8	0.000	

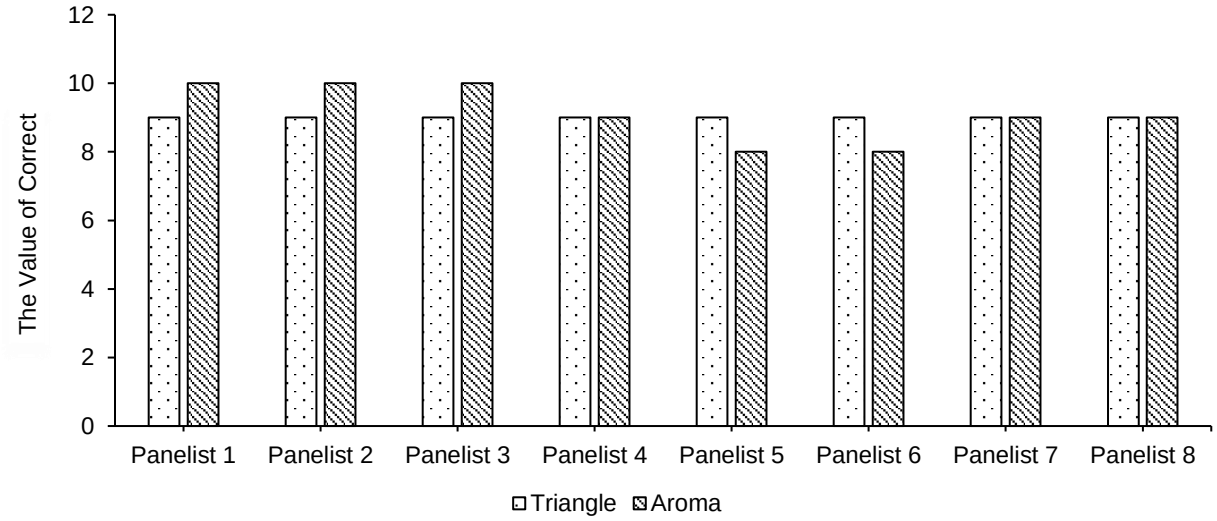

Figure 1. Selection test of triangle and basic aroma

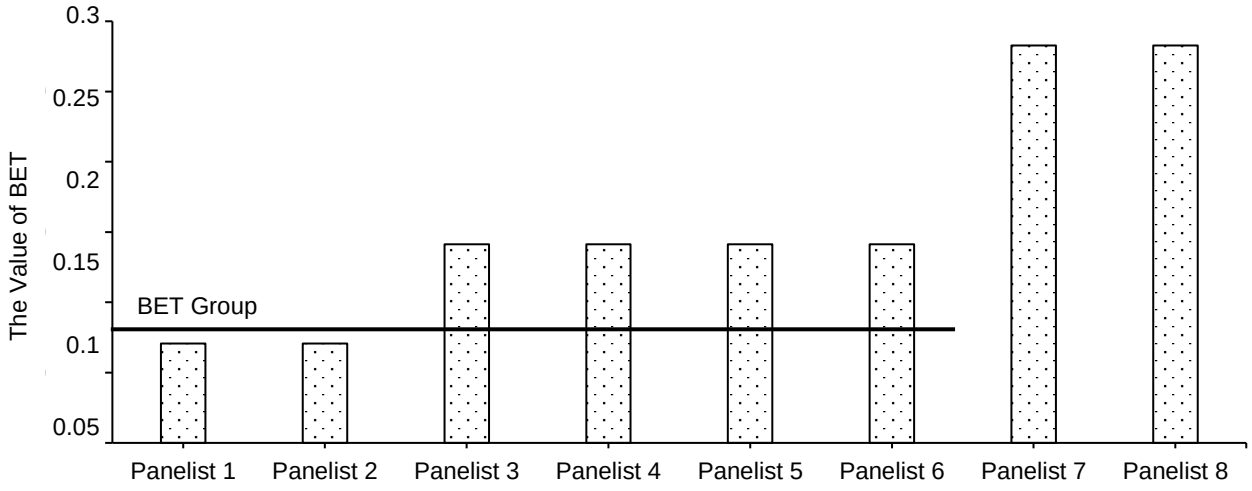

Figure 2. Selection test of threshold

The quantitative descriptive analysis of white tea

Before carrying out the focus group discussion process, the panelists were given 2 white tea samples, which were samples outside the test sample. Then the panelists were asked to identify the attributes in the sample. Panelists were given a number of sensory lexicons related to tea by the panel leader. The trained panelists then discussed and determined the sensory attributes that represented the two white tea samples that had been provided. The results of the focus group discussion can be seen in Figure 3.

Figure 3. Sensory wheel of Indonesian white tea

The sensory profile of white tea is displayed in the form of a biplot principal component analysis (PCA) graph shown in Figure 4, which illustrates the correlation between the sample and the sensory attributes tested with a total of 95.18%, whose data diversity F1 is 69.82% and F2 is 25.35%. In this biplot, there are four quadrants where, if the samples are close together, they are positively correlated or have the same sensory attributes. In contrast, if the samples are the opposite, they are negatively correlated and have different sensory attributes. The analysis showed that in quadrant one of white tea with the Teh Dandang brand, the sensory attributes that dominate are dry aroma, floral aroma, woody aroma, green aroma, green flavor, and floral flavor.

In contrast, white tea from the Heizl brand is the opposite of white tea from the tea brand, whose sensory attributes are dominated by yellow-brown steeping color, burned aroma, burned flavor, fermented flavor, bitter taste, aftertaste bitter, and aftertaste astringent. Then white tea from the PPTK and Ennie 1 brands was compared to the Heizl sample, meaning that both samples had the same sensory attributes: a yellow-brown steeping color, burned aroma, burned flavor, fermented flavor, bitter taste, bitter aftertaste, and a weak astringent aftertaste. Also, the white tea sample from the brand Cap Pucuk is the opposite of the white tea sample from the brand Teh Dandang. It has a dry smell, a floral smell, a woody smell, a green smell, a green flavor, and a weak floral flavor.

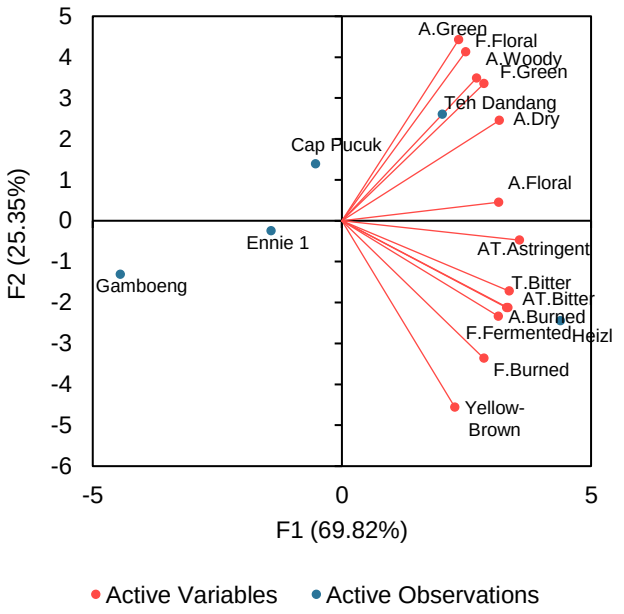

Figure 4. Principle component analysis QDA

This PCA analysis used the Pearson correlation with an alpha value of 0.05. The results show that the burned aroma strongly correlates with the burned flavor, with an R-value of 0.957. Then the green aroma strongly correlates with the green flavor, with an R-value of 0.941. Moreover, the bitter taste strongly correlates with a bitter aftertaste and an astringent aftertaste, with R values of 0.994 and 0.958, respectively. Panelists assessed silver needle white tea with sensory attributes according to Table 2. These sensory attributes were developed through a focus group discussion led by eight trained panelists, yielding a total of 13 sensory attributes in silver needle products. The spider web chart in Figure 5, it can be seen that product Heizl is dominant in the yellow-brown color, burned aroma, floral aroma, burned flavor, fermented flavor, bitter taste, aftertaste bitter, and aftertaste astringent.

Discussion

In this study, white tea was brewed at 98°C, which refers to Pérez-Burillo *et al.* (2018) stated that previous chemical tests, namely the content of bioactive compounds and high antioxidant capacity in tea drinks obtained by brewing them at 98°C were considered the best. The increase in panelists' preference level of only 13% was found at the recommended white tea brewing temperature of

70°C. Similarly, an increase in the panelists' preference level of only 14% was found at the recommended green tea brewing temperature of 80°C. In addition, the aromas of floral, fruity, and green tea predominated in samples of white tea. However, there was an increase in panel preferences of 43% for white tea and 27% for green tea when the brewing temperature increased to 90 and 98°C respectively. According to Rohdiana *et al.* (2013), white tea has the highest polyphenol content when brewed for nine minutes at 95°C. The longer brewing times and the higher brewing temperatures make it easier to remove free radicals. The best way to make white tea with a "clear yellowish" to "yellowish" color, a "slightly sweet" to "sweet" taste, a "tea aroma," and overall acceptance in the range of "like" to "very like" is to start with a temperature of 95°C and brew the tea for 9 minutes (Putra *et al.,* 2020). However, according to Castiglioni *et al.* (2015) research, white tea brewed with cold water and hot water is not significantly different. However, white tea that uses whole leaves is more fragrant when extracted in hot water than in cold water. Panelists rated it "delicious" when whole white tea was brewed with cold water, and panelists preferred to use whole leaf white tea rather than white tea with ground tea leaves.

Table 2. The list of sensory attributes of white tea

Sensory Attributes	Definition
Yellow-Brown	The color of the steeping is a low yellow to brown
Aroma	Smell testing
Aroma Burned	The aroma associated with burning leaves
Aroma Floral	The aroma of a fresh flower, such as a rose
Aroma Dry	The aroma associated with hay
Aroma Woody	The smell of the plant and its fibrous bark
Aroma Green	The smell associated with fresh green leaves
Flavor	When tested while drunk
Flavor Burned	The flavor associated with burning leaves
Flavor Green	The flavor associated with fresh green leaves
Flavor Fermented	The flavor associated with fermented tea
Flavor Floral	The flavor associated with the fresh flower, such as a rose
Taste Bitter	The basic taste of caffeine
Aftertaste Bitter	The bitter taste left at the base of the tongue
Aftertaste Astringent	Dry sensation on the tongue and surface of the mouth

The characteristics of the four different types of tea's sensory profiles are listed in Table 3. All of the types underwent sensory testing using the QDA methodology. Each variety possesses a unique set of qualities, also known as "profile sensory". Differences in the manufacturing process are to blame for this outcome. The aroma of each of the four varieties of tea is the same, including notes of floral, green, fruity, and roasted, and the majority of them have a taste that is bitter. Plain brewed instant white tea evaluated using the QDA method had a higher sweet, floral, green, roasted, woody, and fruity profile than white tea extracted using the simultaneous distillation–extraction (SDE) method. The processes of evaporation, oxidation of aldehydes and characteristic alcohol compounds, hydrolysis of glycosidic precursors, and oxidative breakdown of phenylalanine cause SDE extract to have volatile compounds that are different from those in ordinary brewed white tea. The compounds linalool and trans-β-damascenone work together to make the floral smell and sweetness stronger, while the compounds trans-β-damascenone and camphene work against each other to make the sweetness and green smell weaker (Ni *et al.,* 2020).

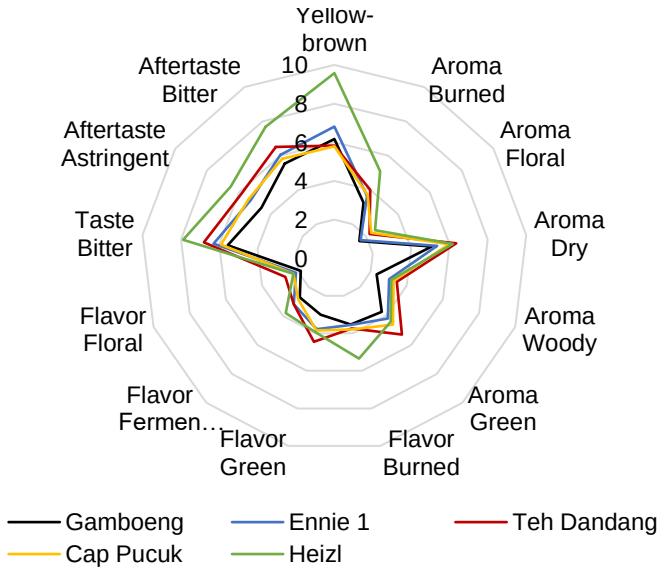

Figure 5. Spider web chart Indonesian white tea

The two primary factors that can affect the sensory quality of brewed white tea are the type of water and the ion content. Pure water has the highest ratings for color, aroma, and taste. The bitter and astringent taste of brewed tea is caused by factors such as EGCG and caffeine compounds, which reach a threshold compared to all other identified taste compounds (Zhang *et al.,* 2017). In addition, tap water, bottled water, and deionized water affect turbidity, color, and EGCG content in brewed green tea and black tea. The less bitter taste and perceived sweeter taste of tea brewed using tap water causes a higher mineral composition than tap water but promotes a higher preference for green tea brewed using tap water. However, green tea drinkers looking for

greater health benefits are advised to brew green tea using purer water. Meanwhile, for drinkers who prioritize more in terms of taste, it is recommended to brew using water from the tap (Franks *et al.,* 2019).

The findings of Castiglioni *et al.* (2015) stated that flowers, resin, walnuts, citrus aroma, bitterness, and astringency taste were dominant in the white tea samples from Africa. The findings of Li *et al.* (2020) revealed that white tea produced from buds and young leaves from China was more likely to be umami-like and smooth, whereas white teas made from fully matured leaves and shoots were frequently discovered to have the characteristics woody and coarse, this complements the woody aroma of white tea from Indonesia with the Teh Dandang brand. Samples of white tea from Indonesia with the brand Teh Dandang also have green aroma attributes; this is consistent with the findings of Ni *et al*. (2020), who discovered that instant white tea samples from China were dominated by the following sensory attributes: sweet, floral, green, fruity, and roasted. While SDE white tea is predominantly woody. In addition, Fan *et al.* (2021) research using white peony-type white tea from China, it has the attributes of sourness, smoothness, astringency, thickness, umami and sweetness. While the Indonesian white tea sample was dominated by the following sensory characteristics: yellow-brown, aroma burned, flavor burned, flavor fermented, taste bitter, aftertaste bitter, and aftertaste astringent.

Tea's bitterness and astringency are influenced by flavonoids and tannins (Zhang *et al.,* 2020a). White tea's bitterness and astringency are related to flavonol compounds, catechin dimers (like thea sinensis and procyanidin B3), and flavonol glycosides (Chen *et al.,* 2020). Caffeine, theobromine, and theophylline, which are included in the alkaloid compounds in tea, are closely related to the specific bitter taste in tea brewing (Zhang *et al.,* 2020b). The strong astringent and bitter taste in tea is caused by polyphenol compounds, namely catechins (Chen *et al.,* 2020). The white tea sample has a bitter taste because white tea contains caffeine compounds ranging from 2.23–4.94% (Tan *et al.,* 2016).

CONCLUSIONS

After sensory profiling by a trained panelist, the white tea of Silver Needle from Indonesia had the following characteristics: yellow-brown, aroma burned, aroma dry, aroma woody, aroma green, aroma floral, flavor green, flavor burned, flavor floral, flavor fermented, bitter, aftertaste bitter, and aftertaste astringent. Heizl attributed sensory characteristics to the sample (yellow-brown, aroma burned, flavor burned, flavor fermented, taste bitter, aftertaste bitter, and aftertaste astringent). Also, the sample of Teh Dandang had a dry aroma, a floral aroma, a woody aroma, a green aroma, a floral flavor, and a floral aroma.

Table 3. The sensory profile of tea types

Sample	Sensory Method	Profile Sensory	Reference
Black tea	QDA	Aroma (sweet, floral, fruity, roasted, spicy, fresh, green, oil, off-odor, woody, smoky, purity, dense, grassy, sour, malty, citrus, resinous); flavor (fruity, sweet, floral, green, fatty)	(Qin *et al.,* 2013; Li *et al.,* 2018; Hou *et al.,* 2020; Yue *et al.,* 2020)
Oolong tea	QDA	Infusion color (honey green, auburn red, dull red, golden yellow, honey yellow, orange red, orange); aroma (roasted, flowery, fruity, clean refreshing, honey, sweet, milky); appearance (pie, bold, heavy, mixed, tight heavy, round tight, coarse loose, short broken, slightly tippy), and taste (mellow sweet aftertaste, stale, clean cool, coarse astringent, brisk smooth, heavy thick, sweet aftertaste, astringent, mellow, umami, bitterness)	(Cai *et al.,* 2016; Wang *et al.,* 2022)
Green tea	QDA, CATA	Aroma (burned, floral, dry, roast, green, fresh green, sweet, fruity, fresh floral, animalic, herbal, pungent); flavor (burned, green, fermented, floral, mid yellow, nutty, roasted, pungent); taste (bitter, umami, sweet, sour); aftertaste (astringent, bitter); mouthfeel (smooth); and appearance (brown, green, yellow)	(Pramudya and Seo, 2018; Adawiyah *et al.,* 2019; Zuo *et al.,* 2021)
White tea	QDA	Aroma (flowers, resin, walnuts, citrus, green, floral, sweet, woody, roasted, fruity); taste (bitter, astringent, umami-like, sour); mouthfeel (smooth, coarse, thickness)	(Castiglioni *et al.,* 2015; Pérez-Burillo *et al.,* 2018; Li *et al.,* 2020; Ni *et al.,* 2020; Fan *et al.,* 2021)

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