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A Lexicon for Descriptive Sensory Evaluation of Blended Tea

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ABSTRACT: A lexicon provides standardized vocabulary that facilitates communication among various objects. We developed a lexicon to describe the sensory flavor and aroma characteristics of fermented tea and blended tea. The 37 sensory attributes of blended tea were identified, defined, and referenced by six highly trained panelists. The lexicon included 24 flavor attributes and 13 aroma attributes. Ingredients in the blended tea included fermented tea, rose petal, lavender, hibiscus, chamomile, peppermint, lemongrass, rosemary, pandanus, and osmanthus. Most of the lexicon attributes were derived from the constituents found in the tea: brown, spicy, cooling, earthy, nutty, sweet, and bitter. Also, attributes derived from the characteristics of the ingredients were included. The lexicon developed in this study can help more accurately describe the flavors and aromas of tea containing fermented tea and herbs.

Keywords: lexicon, blended tea, descriptive analysis, sensory characteristics

INTRODUCTION

In recent years, researches on foods and beverages with high antioxidant and health promoting properties have been conducted steadily (1). Tea from the leaves of *Camellia sinensis* is valued for its aroma, flavor, and health benefits (2). Teas can be categorized according to their level of fermentation and processing: non-fermented, semi-fermented, and fully fermented (3). Tea flavor is influenced by various factors such as the soil, temperature, and variety of the tea bush and manufacturing method (4). In China or Taiwan, fermented tea is made mainly from *Camellia assamica* and usually in autumn. Because of higher temperature and humidity for tea plantations in China and Taiwan, differences in characteristics such as color, taste, and aroma are reported compared to fermented tea produced in Korea (5).

Studies on tea in Korea were conducted mostly on green tea, or imported fermented tea made of *Camellia assamica*. The fermented tea used in this study is a Korean fermented tea made from the tea leaves grown in Korea, also known as *Camellia sinensis*. Korean fermented tea is different from black tea (fermented tea) made of *Camellia assamica*, because it is transparent when brewed; thus, it can show the colors of other ingredients when blended. It is reported to have a deep flavor, but it is not strong, making it suitable as base material for blended tea (6). Studies on Korean fermented tea have focused on physicochemical properties (7), volatile flavor components (8), antioxidant activity (9), and antimicrobial activity (10). However, there are no studies on the characterization and descriptive analysis of blended tea that uses Korean fermented tea.

Herbal tea has many health benefits. It is the world's most popular non-alcoholic beverage (11). Herbal tea is fragrant, has high antioxidant properties and calming effects on the mind (12). Processing has diversified the production of specialty teas, flavored teas, scented teas, and various other blends (3). This diversity contributes to the popularity and economic value of tea. Each has its own taste and flavor, but blending with other ingredients such as leaves, grains, and herbs can affect tea flavor.

Various kinds of blended teas are being newly launched mainly based on ingredient material combinations products by tea manufacturers' experiences. According to a study by Ko and Park (13), tea is a great drink, but blending can boost its efficacy and value. It was reported that blending complements tea and makes it functional, which would greatly contribute to customer satisfaction by improving taste and aroma (14). Therefore, research on blending will contribute to the development of the tea industry, and hopefully will benefit consumers.

A lexicon is a standardized vocabulary that objectively depicts the sensory attributes of consumer products: well

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defined and documented vocabulary supports sensory research. As a business strategy, the role of sensory evaluation is increasing in food and beverage industries. Suppliers of materials and ingredients, fragrances and perfume companies, and consulting firms can continue to outsource sensory evaluation, enabling them to communicate clearly with a variety of companies and consumers (15). The development of a lexicon can quantify the unique characteristics of a product, which is useful in specification and major development targets (16). Lexicons have been published for a wide range of food products, including mango (17), rib steak (18), green tea (19), rooibos tea (20), and brewed coffee (21).

There are studies on tea (19-22) and herbs (23-25), but none report blending of fermented tea and other ingredients (e.g. herbs). Therefore, the objective of this study was to develop a lexicon to describe blended tea (fermented tea and various types of herbs), including the definitions and references for each attribute.

MATERIALS AND METHODS

Tea samples

Twelve blended tea samples (Table 1) were used in this study: a fermented tea (FT), eight types of blended tea that uses fermented tea as base (BT1～BT8), and three commercial blended tea products (OT1～OT3). Blended tea samples with blending ratios were prepared after preliminary sensory tests. Ingredients used in these experiments were FT, and beet as product by Semyungtea (Suncheon, Korea). Citrus peel was purchased from Hanseco-farm (Jeju, Korea); and butterfly fea, pandanus, and osmanthus were purchased from the "gourmet market" in Bangkok, Thailand. Other herb ingredients were purchased from Herb Nuri Co. (Seoul, Korea). Commercial products were produced by Amore pacific Corp. (Seoul, Korea) and purchased from a department store (Busan, Korea).

Tea preparation

One portion of each tea sample was placed into a plastic zipper bag (Ziploc, S.C. Johnson Korea Inc., Seoul, Korea), and stored at room temperature. Tea samples were brewed by adding water and one portion of tea (Table 1) to a Pyrex measuring cup. FT and BT1～BT8 samples were brewed by adding 200 mL of 90°C Samdasoo (Jeju Province Development Co., Jeju, Korea). Teas were brewed for 5 min, then strained using a tea strainer. OT1～OT3 were brewed for 2 min, using 150 mL of 90°C. Brewed tea samples were provided in the amount of 60 mL per 150 mL double-wall thermos-glass mug (Bodum® USA, Inc., New York, NY, USA). For aroma evaluation, one portion of each sample (Table 1) was placed in a 225 mL

Table 1. Tea sample composition information

Samples	Fermented tea	Beet	Butterfly pea	Chamomile	Citrus Peel	Dried ginger	Hibiscus	Jasmine	Lavender	Lemon-grass	Orange cosmos	Osmanthus	Pandanus	Peppermint	Rose hip	Rose-mary	Rose petals	Total weight (g)
FT	1.2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1.2
BT1	1	–	–	0.15	–	–	–	–	–	0.2	0.2	–	–	0.1	–	–	–	1.65
BT2	1	–	–	–	–	–	–	–	0.05	0.3	–	–	–	0.03	0.5	–	–	1.88
BT3	1	0.1	–	0.7	1	–	0.5	–	–	–	–	–	–	–	–	–	–	3.3
BT4	1	–	–	–	1	–	–	–	–	0.5	–	–	0.1	0.02	–	0.1	–	2.72
BT5	1	–	–	–	–	1	–	–	–	–	–	–	–	–	0.5	–	0.5	3
BT6	1	–	–	–	–	–	–	–	–	0.6	–	0.3	–	0.03	–	–	–	1.93
BT7	1	0.1	0.2	–	–	–	0.3	–	0.2	–	–	0.2	–	–	–	–	–	2
BT8	1	–	–	0.15	0.5	–	–	0.4	–	–	–	–	–	–	–	–	–	2.05
OT1	○	–	–	–	○	–	–	–	–	–	–	–	–	–	–	–	–	1.7
OT2	○	–	–	–	–	–	○	–	–	–	–	–	–	–	○	–	○	1.5
OT3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	○	–	○	1.8

OT1, Samdayeon Jeju tangerine (O'sulloc, Jeju, Korea), and ingredients were fermented tea, Jeju tangerine mix, sweet tangerine flavor; OT2, A village road full of fragrance of cherry blossom (O'sulloc), and ingredients were fermented tea, black tea, Jeju cherry blossom flavor, rose petal, hibiscus, apple, rose hip, pineapple; OT3, Red papaya black tea (O'sulloc), and ingredients were black tea, rose hip, papaya dice, peach flavor, rose petal.

brandy glass and covered with a watch glass. The samples were prepared 12 h before the experiment.

Panelists

A highly trained descriptive panel participated in this study. Six panelists were comprised of females between 40 and 70 years of age. The panelists had received at least 110 h of general sensory tests, including coffee and milk tea with descriptors similar to those found in tea. This study was reviewed and approved by the Pusan National University Institutional Review Board (IRB PNU IRB/2016_135_HR).

Development of definitions and references

Using the 12 tea samples, the panelists developed a preliminary terminology describing the flavor and aroma characteristics of fermented tea and blended tea. Before the experiment, researchers did not inform the panelists about tea samples (e.g., kind of tea, composition of herbs, and brewing methods) to avoid bias. The panelists evaluated each tea several times and created preliminary descriptors. Through panel discussions, each term was defined. A total of 13 h was spent, and a total of 36 blended tea character terms, including the overall impression, were developed. Of the total 24 flavor attributes, 11 flavor attributes (rose, lavender, hibiscus, chamomile, osmanthus, jasmine, citrus, fruit flavor, rosemary, lemongrass, peppermint, and pandanus) were also used for aroma evaluation of dried tea. After developing the lexicon with references, the intensity of the characteristics of each sample was evaluated using a 0∼15-point intensity scale with 0.5-point increments; 0 indicated "none" and 15 indicated "very strong." When evaluating samples using the developed lexicon, standard reference materials were presented to ensure a more accurate evaluation. Three replicates were conducted, and the serving order followed the randomized complete block design. In between sample tasting, bottled water and non-salt crackers were used to rinse the mouth. Evaluation was performed in an independent booth to minimize external stimuli.

Data analysis

Analysis of variance (ANOVA) was conducted to evaluate differences among samples. When the independent variable showed a significant effect, Fisher's least significant difference was performed. Principal component analysis (PCA) was applied to the mean values of sensory attributes to visualize and help understand the relationship between the samples and the attributes. PCA was conducted using the covariance matrix extraction method with no rotation. All analyses were conducted using SAS® version 9.4 (SAS Institute Inc., Cary, NC, USA).

RESULTS AND DISCUSSION

Lexicon development

Sensory attributes and definitions for fermented tea and blended tea were developed by the panel as detailed in Table 2 and 3. Among the descriptive terms obtained upon agreement through panel discussions, 24 characteristics and standard flavor references were selected: overall intensity, black tea, rose, hibiscus, chamomile, jasmine, and peach. In addition, aroma characteristics of the tea were evaluated based on taste characteristics. These included rose, lavender, hibiscus, chamomile, and rosemary. A total of 13 descriptive terms for fragrance were developed.

The characteristics derived from this study are result from the mixed ingredients or the fragrant herb materials. As shown in Table 1, the blending ratio of fermented tea in blended tea of BT1 to BT8 is the same in 1 g; it is about 30 to 60% of the tea weight. In this study, various herbs such as lavender, lemongrass, and peppermint were mixed, in addition to the fermented tea. Also, the type of organoleptic characteristic expressed was judged to have changed due to differences in the added amounts.

Lee et al. (26) reported that bitter taste, astringency, oolong tea, brown rice, roasted grain, chestnut shell, dried straw, arrowroot, and burnt leaf were used to describe the sensory attributes of green tea. Also, terms such as metallic aroma, wax gourd-drink aroma, astringency, bitterness, oolong tea flavor, fermented tea flavor, and alkaline flavor were used as attributes in descriptions in the study of an oolong tea drink (22). Typically, descriptive analysis is performed using a set of individual samples within the category that forms the "frame of reference" for the panel (27). In the type of sample called "blended tea," the lexicon for the flavor and aroma of a sample derived in this study can be changed as the blended tea mixed material or ratio changes. In the present work, the frame of reference used was limited to the fermented tea used in the preparation of the sample, some herbs, and ingredients contained in commercial products.

A lexicon of 24 flavor and 13 aroma descriptive attributes was developed, defined, and referenced for fermented tea and blended tea. Using the lexicon of this study, researchers can more accurately describe the flavor and aroma of a tea that contains the herbs used in this study. It can also be related to other chemical, physical, or sensory information.

Sensory characteristics

The quantitative sensory descriptive analysis was investigated for the attributes developed for the blended tea used in this study. The results of the flavor analyses are summarized in Table 4. In order to visually summarize their sensory characteristics, PCA were performed on fla-

Table 2. Definition of flavor attributes for blended tea evaluation

Attributes	Definition	Reference
Overall intensity	The maximum intensity of the overall impact during the entire evaluation session	Overall intensity=4.0[1)] Take 1 tea bag of Lipton Yellow Label tea (Unilever Korea, Daejeon, Korea), add 450 mL of 98°C water, and brew for 90 s. Overall intensity=7.0 Take 3 tea bags of English breakfast tea (R Twining and Company Sp. z o.o., Jasin, Poland), add 600 mL of 98°C water, and brew for 3 min. Overall intensity=9.0 Take 3 tea bags of Lipton Yellow Label tea (Unilever Korea), add 450 mL of 98°C water, and brew for 90 s.
Black tea	A characteristic flavor of black tea, flavor of fermented and browned, accompanied with slight bitter and sour	Black tea=3.0 Take 1 tea bag of Lipton Yellow Label tea (Unilever Korea), add 450 mL of 98°C water, and brew for 90 s. Black tea=6.0 Take 3 tea bags of English breakfast tea (R Twining and Company Sp. z o.o.), add 600 mL of 98°C water, and brew for 3 min. Black tea=7.0 Take 3 tea bags of Lipton Yellow Label tea (Unilever Korea), add 450 mL of 98°C water, and brew for 90 s.
Brown	Dark brown impression with soft, toasted nutty, toasted flavor, and sweet characteristics	
Rose	A sweet and soft floral fragrance associated with fresh or dried roses	Rose=6.0 Weigh 2 g of rose petal (GDG Schütte GmbH & Co. KG, Bremen, Germany), infuse with 400 mL of boiling water (98°C) for 5 min. Filter and serve the liquid part.
Lavender	Lavender aromatics associated with floral; may and may not be accompanied by earthy and freshly cut mugwort	Lavender=6.0 Take 2 tea bags of lavender tea (E-Mart, Seoul, Korea), add 400 mL of 98°C water, and infuse for 5 min.
Hibiscus	Sour, astringent, and salty, commonly associated with hibiscus	Hibiscus=8.0 Take 2 tea bags of hibiscus tea (Tea and Chemical Electronics Co., Ltd., Gunpo, Korea), add 400 mL of 98°C water, and infuse for 2 min.
Chamomile	A floral scent commonly associated with chamomile; may be accompanied with slight pungency	Chamomile=5.0 Take 2 tea bags of chamomile tea (Tea and Chemical Electronics Co., Ltd.), add 400 mL of 98°C water, and infuse for 2 min.
Osmanthus	A floral scent accompanied with a spicy odor like red pepper seed, and sour aromatics; leaves a bitter aftertaste	Osmanthus=4.0 Weigh 1 g of sweet osmanthus (Healthy Living Co., Ltd., Bangkok, Thailand), add 400 mL of 98°C water, and infuse for 5 min. Filter and serve the liquid part.
Jasmine	Aromatics of dried jasmine and acacia flowers, somewhat green with slightly bitter and astringent	Jasmine=4.0 Weigh 2 g of jasmine flower herb tea (GDG Schütte GmbH & Co. KG), add 400 mL of 98°C water, and infuse for 5 min. Filter and serve the liquid part.
Citrus	Citrus flavor of clementine citrus accompanied with nutty and sweet	Citrus=4.0 Take 1 tea bag of citrus peel tea (Jeju organic tangerine peel tea, Dongwoodang Pharmacy Co., Ltd., Yeongcheon, Korea), add 400 mL of 98°C water infuse for 5 min.
Peach	Floral and fruity aromatics associated with peaches	Peach=4.0 Weigh 14 g of Lipton Ice Tea peach (Unilever Korea) and mix with 400 mL water. Serve 2 tablespoons in a cup.
Cherry	Sour and sweet aromatics commonly associated with cherries	Cherry=4.0 Charms Minipops (Tootsie Roll Industries, Chicago, IL, USA) cherry flavor, serve one piece.
Rosemary	Fragrance of roses accompanied with a cooling sensation similar to mint, and slight spiciness similar to ginger. And lingering sensation for long	Rosemary=6.0 Take 2 tea bags of rosemary tea (Tea and Chemical Electronics Co., Ltd.), add 400 mL of 98°C water and infuse for 2 min.
Lemongrass	Sweet, lemony or citrus flavor, leaves a ginger-like aftertaste, typically associated with lemongrass	Lemongrass=6.0 Weigh 2 g of lemongrass cut (GDG Schütte GmbH & Co. KG), add 400 mL of 98°C water, infuse for 2 min. Filter and serve the liquid part.

Table 2. Continued

Attributes	Definition	Reference
Peppermint	Cooling sensation and herbal aromatics commonly associated with peppermint	Peppermint=5.5 Take 2 tea bags of peppermint tea (Tea and Chemical Electronics Co., Ltd.), add 400 mL of 98°C water and infuse for 2 min.
Pandanus	Nutty aromatics similar to Solomon's seal tea, and vegetables and umami associated with dried fish proteins	Pandanus=5.0 Weigh 1 g of pandanus leaf (Healthy Living Co., Ltd.), add 400 mL of 98°C water, and infuse for 5 min. Filter and serve the liquid part.
Ginger	A sweet, citrus/lemon, and pungent-like aromatics, commonly associated with ground ginger	Ginger=3.0 Weigh 0.6 g of freeze-dried ground ginger (Sanmaeul, Changnyeong, Korea), add 200 mL of water, and infuse for 2 min. Filter and serve the liquid part.
Spicy	Spicy flavor and burning sensation coming from condiment vegetables such as ginger	Spicy=2.0 Weigh 0.6 g of freeze-dried ground ginger (Sanmaeul), add 200 mL of water at ambient temperature, and infuse for 2 min. Filter and serve the liquid part.
Nutty	Nutty flavor such as grain, crust of overcooked rice, and slightly sweet	Nutty=3.0 Weigh 10 g of brown rice tea (CHUNGO, Gwangju, Korea), add 500 mL of 98°C water, and infuse for 10 min. Filter and serve the liquid part.
Earthy	Somewhat wet, heavy aromatics associated with decaying vegetation and wet soil	Button mushrooms Remove the stems, and slice the fresh button mushrooms (Lotte Mart, Busan, Korea). Place three pieces in a brandy glass. Cover the watch glass.
Sweet	A basic taste of which sugar in water is typical	0.5% sucrose solution (Fisher Scientific UK, Loughborough, UK)=0.5; 1% sucrose solution=1.0.
Bitter	A basic taste of which caffeine in water is typical	0.01% caffeine (Sigma-Aldrich Co., St. Louis, MO, USA) solution=2.0; 0.02% caffeine solution=3.5; 0.035% caffeine solution=5.0.
Sour	A basic taste factor of which citric acid in water is typical	0.015% citric acid (Fisher Scientific UK) solution=1.5; 0.03% citric acid solution=2.5.
Salty	A basic taste factor of which salt in water is typical	0.15% sodium chloride (Fisher Scientific UK) solution=1.5.
Astringency	Drying, puckering sensation on the tongue and other mouth surfaces	0.03% alum (McCormick & Company, Inc., Sparks, MD, USA) solution=1.5; 0.05% alum solution=2.5; 0.10% alum solution=5.0.

[1)]Intensity, 15-point scale with 0.5-point increments (0=none, 15=extreme).

vor and aroma separately (Fig. 1 and 2).

In the flavor results, except for overall intensity, black tea, bitter, and astringency, all flavors were generally reported as less than 0.5, more often less than 0.4, or 0.0 on a 15-point scale (Table 4). The sample showing the strongest overall intensity was BT1 at 4.6 points. Samples with the strongest flavor of black tea were FT, BT1, BT5, OT1, and OT2. BT2, BT3, and BT7 showed the lowest intensity for black tea flavor at 0.9 and 0.8 points respectively. For BT8, the descriptive term which showed the highest intensity (3.3 points) was the brown flavor. Next was hibiscus flavor at 2.7 points, appearing most strongly in BT3. Cherry flavor at 2.2 points in OT3, followed by the peach flavor at 2.1 points in OT2 were also among the highly-scored. All term scores were below 2.0 points, except for the brown flavor of BT8, the hibiscus flavor of BT3, the cherry flavor of OT3, and the peach flavor of OT2. Fig. 1 shows the results of PCA of the blended tea sample sensory flavor data. The flavor PC1 explained 26% of the variation, and had positive loadings for chamomile, lavender, cooling, sour, nutty, and lemongrass. BT1, BT2, BT4, and BT6 samples have these characteristics. PC2 explained 21% of the variation, and had positive loadings for lavender, hibiscus, sour, and salty.

It is important to note that the product intensity level of a characteristic is relatively comparable with the reference value used in each study (28). FT had higher scores in black tea flavor and nutty than any other sample; it was well defined by these two characteristics (Table 4, Fig. 1). Overall intensity, and peppermint was relatively strong in BT1; and osmanthus, peach, cherry, pandanus, earthy, and salty characteristics were not expressed. BT2 sample showed relatively strong lemongrass, ginger, and spicy characteristics; rose, hibiscus, peach, cherry, pandanus, earthy, and salty characteristics were not expressed. BT3 had higher hibiscus flavor, sour taste, and salty taste than any other sample, and was clearly defined by these properties. This is thought to be due to the sour taste eluted from the citrus peel and hibiscus in BT3. An earlier study described the odor and flavor of hibiscus infusions as strong and sour (29). Also, according to a study by Monteiro et al. (30), elicitations of check-all-that-apply term "strong in hibiscus" were sig-

Table 3. Definition of aroma attributes for blended tea evaluation

Attributes	Definition	Reference
Rose	A sweet, soft floral fragrance associated with fresh or dried roses	Rose petal aroma=12.0[1)] Weigh 1 g, rose petals herb tea (GDG Schütte GmbH & Co. KG). Put in a brandy glass. Cover the watch glass.
Lavender	Lavender aromatics associated with floral; may and may not be accompanied by earthy and freshly cut mugwort	Lavender aroma=10.0 Weigh 0.5 g of lavender tea (E-Mart). Remove thread and tea bag. Put in a brandy glass. Cover the watch glass.
Hibiscus	Scent of hibiscus, fermented and musty odors reminiscent of old dried plums; slightly sweet	Hibiscus aroma=6.0 1 tea bag of hibiscus tea (Tea and Chemical Electronics Co., Ltd.). Remove thread. Put in a brandy glass. Cover the watch glass.
Chamomile	Chamomile floral fragrance, slightly musty, associated with dried flowers	Chamomile aroma=10.0 1 tea bag of chamomile tea (Tea and Chemical Electronics Co., Ltd.). Remove thread. Put in a brandy glass. Cover the watch glass.
Osmanthus	Osmanthus floral fragrance, spicy pungent odor similar to curry, a complex odor with a combination of sweet, sour, and salty odor	Osmanthus aroma=12.0 Weigh 1 g sweet osmanthus (Healthy Living Co., Ltd.). Put in a brandy glass. Cover the watch glass.
Jasmine	Dried jasmine floral and sweet odor, somewhat musty unique to dried flowers	Jasmin aroma=7.0 Weigh 1 g jasmine flower herb tea (GDG Schütte GmbH & Co. KG). Put in brandy glasses. Cover the watch glass.
Citrus	Combination of sweet, nutty, sour, and clementine citrus aroma	Citrus peel aroma=7.0 1 tea bag (2 g) of citrus peel tea (Dongwoodang Pharmacy Co., Ltd.). Remove thread and tea bag. Put in a brandy glass. Cover the watch glass.
Rosemary	Fragrance of roses accompanied with a cooling sensation similar to mint; slight spiciness similar to ginger; lingering sensation for long	Rosemary aroma=9.0 1 tea bag of rosemary tea (Tea and Chemical Electronics Co., Ltd.). Remove thread and tea bag. Put in a brandy glass. Cover the watch glass.
Lemongrass	Slight lemon odor and dried hay aroma	Lemongrass aroma=6.0 Weigh 1 g. Put in a brandy glass. Cover the watch glass.
Peppermint	Cooling sensation and herbal aromatics commonly associated with peppermint	Peppermint aroma=7.0 1 tea bag of peppermint tea (Tea and Chemical Electronics Co., Ltd.). Remove thread. Put in a brandy glass. Cover the watch glass.
Pandanus	Combination of green and umami odor from dried fish proteins	Pandanus aroma=10.0 Weigh 0.5 g of pandanus leaf (Healthy Living Co., Ltd.). Put in a brandy glass. Cover the watch glass.
Cooling	Cooling sensation in the nose when smelling mint or menthol	Polo=9.0 1 Polo original candy (Nestle Tianjin Ltd., Tianjin, China). Put in brandy glasses. Cover the watch glass.
Earthy	Somewhat wet, heavy aromatics associated with decaying vegetation and wet soil	Button mushrooms Remove the stems, and slice the fresh button mushrooms (Lotte Mart). Put three pieces in a brandy glass, and cover the watch glass.

[1)]Intensity, 15-point scale with 0.5-point increments (0=none, 15=extreme).

nificantly correlated to trained panelists' evaluations of "acid taste," but not of hibiscus odor or flavor as would be expected. BT4 samples showed relatively strong characteristics of citrus, lemongrass, pandanus, spicy, nutty, peppermint, and rosemary. BT4 is thought to be a blending ratio that can have the flavor of all added materials. BT5 samples were evaluated as relatively strong in rose and black tea, and weak in other properties. BT6 showed stronger rosemary, lemongrass, spicy, and cooling characteristics. BT6 consists of fermented tea, lemongrass, osmanthus, and peppermint. Among the relatively strong characteristics, spicy is thought to be influenced by osmanthus, which is spicy as defined in lexicon. The materia medica of the osmanthus flower is spicy, warm, and non-toxic (31). Also, the cooling characteristic is thought to be an effect of peppermint. The characteristics of lavender, earth sour, and salty were relatively strong in BT7, and those of brown, chamomile, and jasmine were stronger in BT8 samples. Salty, which was expressed as a stronger characteristic in BT7, was expressed relatively strongly in BT3, probably because it contained hibiscus. In the lexicon definition for hibiscus, salty was also included, and hibiscus was attributed to only BT3 and BT7.

OT1 showed stronger characteristics of black tea, peppermint, bitter, and astringency than the other samples; OT2 showed peach; and OT3 showed cherry and sweet

Table 4. Analysis of variance of flavor characteristics present in blended tea

Sample	Overall intensity	Black tea	Brown	Rose	Lavender	Hibiscus	Chamo-mile	Osmanthus	Jasmine	Citrus	Peach	Cherry	Rosemary
FT	4.0^{bc}	1.5^{a}	0.7^{b}	0.1^{c}	0.8^{ab}	0.0^{e}	0.2^{de}	0.2^{b}	0.0^{c}	0.5^{ab}	0.0^{b}	0.0^{b}	0.0^{e}
BT1	4.6^{a}	1.4^{ab}	0.7^{b}	0.2^{bc}	0.8^{ab}	0.2^{de}	0.7^{ab}	0.0^{b}	0.2^{bc}	0.3^{bcdef}	0.0^{b}	0.0^{b}	0.3^{bcde}
BT2	3.9^{bc}	0.9^{de}	0.6^{b}	0.0^{c}	0.8^{ab}	0.0^{e}	0.6^{bc}	0.0^{b}	0.0^{c}	0.4^{bcde}	0.0^{b}	0.0^{b}	0.4^{abc}
BT3	4.0^{bc}	0.8^{e}	0.6^{b}	0.0^{c}	0.5^{bcd}	2.7^{a}	0.8^{ab}	0.0^{b}	0.0^{c}	0.0^{g}	0.0^{b}	0.0^{b}	0.0^{e}
BT4	3.9^{c}	1.0^{cde}	0.6^{b}	0.0^{c}	0.2^{de}	0.0^{e}	0.0^{e}	0.2^{b}	0.0^{c}	0.7^{a}	0.0^{b}	0.0^{b}	0.4^{ab}
BT5	4.1^{bc}	1.3^{abc}	0.6^{b}	1.3^{a}	0.3^{cde}	0.6^{c}	0.4^{cd}	0.0^{b}	0.2^{bc}	0.3^{cdefg}	0.0^{b}	0.0^{b}	0.2^{cde}
BT6	3.9^{c}	1.1^{bcd}	0.6^{b}	0.0^{c}	0.6^{abc}	0.0^{e}	0.4^{cd}	0.2^{b}	0.2^{c}	0.4^{bc}	0.0^{b}	0.0^{b}	0.5^{a}
BT7	4.3^{ab}	0.8^{de}	0.7^{b}	0.2^{bc}	1.0^{a}	1.9^{b}	0.2^{de}	0.3^{b}	0.0^{c}	0.0^{g}	0.0^{b}	0.0^{b}	0.3^{abcd}
BT8	4.2^{bc}	1.1^{bcd}	3.3^{a}	0.0^{c}	0.2^{de}	0.0^{e}	0.9^{a}	0.0^{b}	1.4^{a}	0.4^{bcd}	0.0^{b}	0.0^{b}	0.0^{e}
OT1	4.3^{ab}	1.6^{a}	0.7^{b}	0.2^{bc}	0.0^{e}	0.3^{d}	0.2^{de}	0.6^{a}	0.4^{b}	0.4^{bcde}	0.0^{b}	0.2^{b}	0.2^{cde}
OT2	3.8^{c}	1.3^{abc}	0.7^{b}	0.2^{bc}	0.0^{e}	0.2^{de}	0.0^{e}	0.0^{b}	0.0^{c}	0.0^{g}	2.1^{a}	0.0^{b}	0.0^{e}
OT3	4.1^{bc}	1.1^{bcd}	0.8^{b}	0.3^{b}	0.0^{e}	0.3^{d}	0.0^{e}	0.0^{b}	0.0^{c}	0.2^{defg}	0.0^{b}	2.2^{a}	0.0^{e}
LSD[1)]	0.37	0.33	2.24	0.22	0.38	0.24	0.29	0.24	0.25	0.24	0.13	0.24	0.27

Sample	Lemon-grass	Pepper-mint	Pandanus	Ginger	Spicy	Cooling	Earthy	Nutty	Sweet	Bitter	Sour	Salty	Astringency
FT	0.0^{d}	0.0^{d}	0.0^{b}	0.0^{c}	0.0^{d}	0.2^{f}	0.0^{b}	0.6^{ab}	0.4^{bc}	0.7^{c}	0.0^{e}	0.0^{c}	0.9^{cd}
BT1	1.1^{b}	0.6^{a}	0.0^{b}	0.3^{b}	0.3^{b}	0.5^{ab}	0.0^{b}	0.5^{bc}	0.4^{bc}	0.5^{c}	0.4^{cd}	0.0^{c}	0.8^{cd}
BT2	1.9^{a}	0.4^{abc}	0.0^{b}	0.6^{a}	0.5^{a}	0.6^{ab}	0.0^{b}	0.4^{cd}	0.5^{ab}	0.6^{c}	0.4^{bcd}	0.0^{c}	0.6^{e}
BT3	0.0^{d}	0.2^{bc}	0.0^{b}	0.0^{c}	0.0^{d}	0.3^{def}	0.0^{b}	0.3^{de}	0.5^{ab}	0.4^{c}	1.3^{a}	0.4^{a}	1.1^{ab}
BT4	1.7^{a}	0.4^{ab}	0.4^{a}	0.4^{b}	0.5^{a}	0.5^{abcd}	0.0^{b}	0.7^{a}	0.4^{bc}	0.5^{c}	0.3^{d}	0.0^{c}	0.6^{e}
BT5	0.5^{c}	0.3^{bc}	0.0^{b}	0.0^{c}	0.2^{cd}	0.3^{ef}	0.0^{b}	0.5^{bc}	0.4^{abc}	0.6^{c}	0.5^{bc}	0.0^{c}	1.0^{bc}
BT6	2.0^{a}	0.3^{bc}	0.0^{b}	0.5^{ab}	0.5^{a}	0.6^{a}	0.0^{b}	0.4^{cd}	0.4^{abc}	0.5^{c}	0.4^{bcd}	0.0^{c}	0.7^{de}
BT7	0.2^{cd}	0.4^{abc}	0.0^{b}	0.0^{c}	0.2^{bc}	0.4^{bcd}	0.2^{a}	0.3^{e}	0.4^{c}	0.5^{c}	1.1^{a}	0.3^{b}	1.0^{bc}
BT8	0.3^{cd}	0.3^{abc}	0.0^{b}	0.0^{c}	0.0^{d}	0.4^{cde}	0.0^{b}	0.5^{bc}	0.5^{ab}	0.5^{c}	0.3^{cd}	0.0^{c}	0.7^{de}
OT1	0.0^{d}	0.6^{a}	0.0^{b}	0.0^{c}	0.0^{d}	0.4^{bcd}	0.0^{b}	0.4^{cd}	0.4^{c}	1.6^{a}	0.5^{bc}	0.0^{c}	1.3^{a}
OT2	0.0^{d}	0.4^{ab}	0.0^{b}	0.0^{c}	0.0^{d}	0.4^{bcd}	0.0^{b}	0.4^{cd}	0.5^{ab}	1.0^{b}	0.5^{b}	0.0^{c}	1.1^{ab}
OT3	0.0^{d}	0.4^{abc}	0.0^{b}	0.0^{c}	0.0^{d}	0.5^{abc}	0.0^{b}	0.4^{cd}	0.5^{a}	0.7^{bc}	0.5^{b}	0.0^{c}	0.9^{bc}
LSD	0.37	0.27	0.12	0.17	0.15	0.16	0.10	0.13	0.07	0.33	0.17	0.11	0.20

Evaluated using an incremental scale from 0 to 15 in 0.5-point increments (0=none, 15=extremely strong).
The different letters (a-g) in the same column are significant among the sample for each attribute at $P<0.05$.
Rounded off the numbers to two decimal places, then rounded to zero those that were less than 0.2.
[1)]LSD, least significant difference.

characteristics. The characteristics of peach appeared only in OT2, and the characteristic of cherry only appeared in OT3. OT group samples showed higher overall intensity, black tea, bitter, and astringency than FT and BT groups.

A sensory panel determined that 13 aroma features could be used to represent the tea samples used in this investigation. Properties that have been shown not to be significantly different are excluded from the previous data set.

In the aroma results, compared to the quantitative results of the flavors described above, most of the samples with relatively strong results for each attribute were consistent. Although the data are not shown, the highest score for the rose aroma attribute was 1.5 points in the BT5 sample. Next was chamomile with 1.3 points in BT3. Chamomile aroma was recognized in the BT group and not in the FT and OT groups. Chamomile is a term that frequently appears in sensory analyses of food. Sensory analysis studies of coffee (32), milk tea (33), honey (34), and wheat bread (35) all used attributes for chamomile. This may be because chamomile contains compounds of various flavor characteristics. The volatile component of chamomile contains chemical components contained in mugwort, green tea, lavender, citrus, mint, sweet sandal tree, cloves, pine, celery, and jasmine flowers (36). Osmanthus and citrus were strong in BT6 and BT8 at 1.2 points. Except for the above-mentioned aroma attribute, all attributes were measured at less than 1.2 points. Among them, pandanus was at 1.0 in BT4, and not detected at all in other samples. This is consistent with ingredients for tea. The BT4 sample can be considered as a tea with characteristics of pandanus aroma. According to Jiang's research (37), 3-methyl-2(5H)-furanone is the most important compound in the aroma of pandanus. A pure standard of 3-methyl-2(5H)-furanone gives an aroma that is characterized as caramel, sweet, honey, and a bit of medicinal note. Although this compound does not resemble the typical pandan-like smell, it could be an important contributor to the overall aroma of pandanus, especially the undertone of pandanus aroma (37).

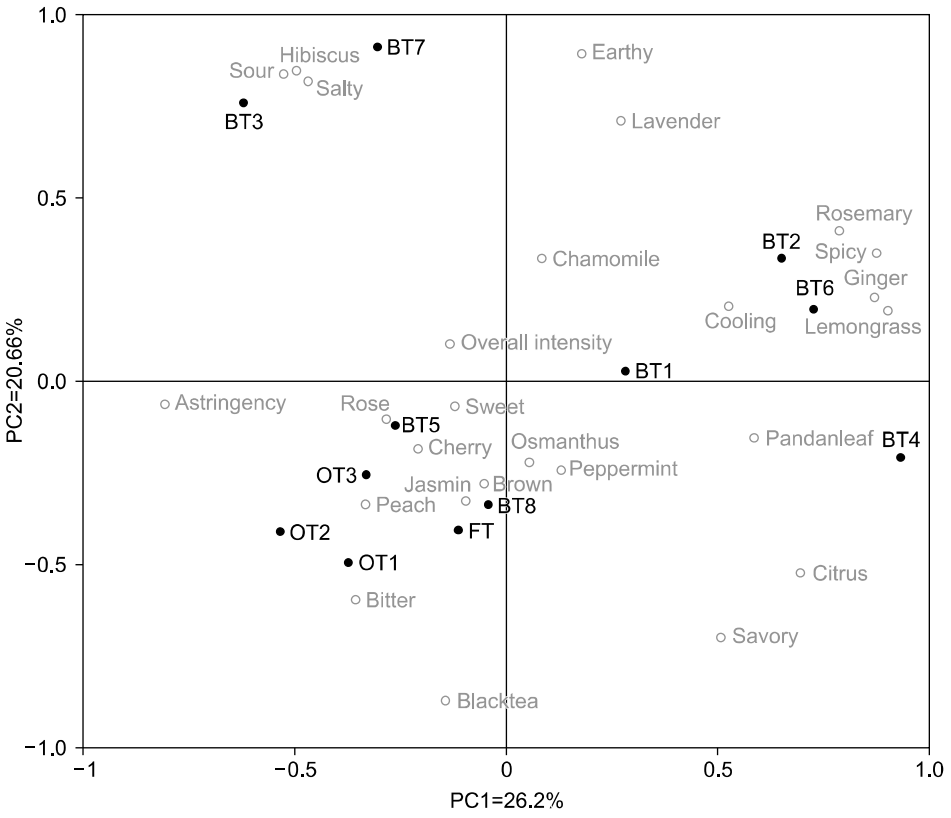

Fig. 1. Principal component (PC) analysis biplot showing both flavor sensory attributes and tea samples.

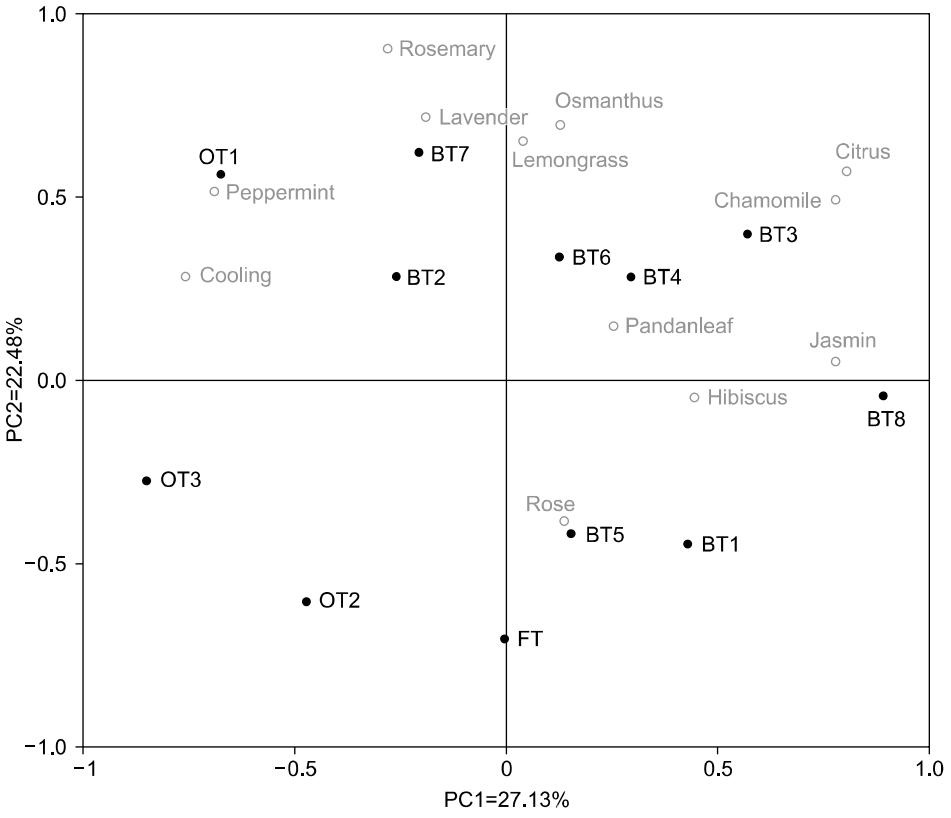

Fig. 2. Principal component (PC) analysis biplot showing both aroma sensory attributes and tea samples.

Fig. 2 shows the PCA results of the blended tea samples sensory aroma data, which explained 49% of the variation. PC1 explained 27% of the variation, and had positive loadings for citrus, jasmine, chamomile, and hibiscus. Most of the BT group has these characteristics. PC2 explained 22% of the variation, and had positive loadings for rosemary, lavender, osmanthus, lemongrass, citrus, and peppermint.

The most consistent characteristics and strength of the samples were rose, lavender, chamomile, jasmine, citrus,

lemongrass, peppermint, and pandanus. Hibiscus, osmanthus, rosemary, and cooling were not consistent in value. The flavor sensory characteristics of osmanthus appeared relatively strong in OT1, which does not contain osmanthus. However, the sensory characteristics of the fragrance were strong in BT6 containing osmanthus. This result shows that osmanthus gives a strong impression when it is taken as raw material, but when it is infused in tea, its characteristics are subdued. Sanderson and Grahamm (38) indicated that under the conditions of the conventional tea extraction method, the flavor of tea is determined by the combined effects of non-volatile solids which can be extracted from tea leaves.

In conclusion, a lexicon containing 24 flavor and 13 aroma descriptive attributes was developed, defined, and referenced for blended tea using fermented tea. Utilizing this lexicon, researchers can more precisely describe the flavor and aroma of a tea that contains the herbs used in this study. The results can be related to other chemical, physical, or sensory information, and benefit tea manufacturers and consumers.

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AUTHOR DISCLOSURE STATEMENT

The authors declare no conflict of interest.

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