DEVELOPMENT OF A COFFEE LEXICON AND DETERMINATION OF DIFFERENCES AMONG BREWING METHODS

by

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Abstract

A total of more than 100 different coffee samples from 14 countries around the world were used to create a coffee lexicon. The first list of terms consisted of 74 attributes that were developed from the review of 13 samples from Colombia. A second development incorporated an existing commercial lexicon and examined an additional of 72 coffee samples from different parts of the world. Validation sessions were also performed with 20 samples from the area of San Adolfo, Colombia. Principal Component Analysis (PCA) was used to mapped the scores obtained during the validation phase of the terminology, the panelists were able to describe specific characteristics that were present in the coffee samples such as sweet, nutty and fruity notes, as well as the differentiation of notes such as burnt, smoky, astringent, acrid and bitter. At the end of the process, a total of 110 attributes and their references were identified. Another study was conducted to identify the sensory properties of three coffee samples using four different brewing methods. The coffee samples were prepared using a consumer drip coffee maker, a home or food service automated espresso machine, a coffee grader "cupping" method and a filtered infusion method. The cupping method produced a higher intensity for the "roasted" flavor attribute across all samples. This method also tended to produce higher scores for burnt and acrid than other brewing methods. Flavor and aroma attributes both varied with preparation methods, but not necessarily in the same ways. The drip brewing method showed the most differences in the three coffee samples for aroma, flavor and aftertaste attributes, but other methods may be appropriate depending on the objectives of each study.

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Chapter 1 - Literature Review

Coffee

Coffee Cultivars

Coffee (Coffea) is part of the Rubiaceae family; this family includes over 500 genera and over 6000 species. By itself Coffee includes numerous species but only two of them are of real economic importance: *Coffea Arabica* and *Coffea Canephora* var. Robusta. Coffee Arabica represents the 60-70% of world production, and, Robusta represents the 30-40% of the global production (International Trade Centre, 2011; Dicum & Luttinger, 1999).

According to the literature, Arabica and Robusta species differ in flavor, caffeine content, disease resistance, and optimum cultivation conditions. Natural variations in soil, sun, moisture, slope, illness and pest conditions dictate which coffee is most effectively cultivated in each region of the world (Dicum & Luttinger, 1999).

Coffea Arabica and *Coffea Canephora* have a distinct chemical composition. According to literature, Arabica coffees tend to produce higher quality coffees, however, Robusta coffee trees are stronger, and they tend to be more resistant to diseases when compare to the Arabica ones. Another difference is the content of chlorogenic acids and caffeine (content of caffeine in Robustas is about two times the content in Arabicas), both tend to be higher in robustas, research shows that higher content of these acids will generate low-quality coffees (Farah, 2009; Farah, Monteiro, Calado, & Trugo, 2006).

Table 1-1 shows the chemical composition of the non-volatile components of roasted coffee beans. Sucrose and lipids like triglycerides and diterpene esters tend to be higher in arabicas than in robustas. On the other hand, some polysaccharides like arabinogalactan, mannan and glucan tend to be higher in robustas when compared to arabicas (Farah, 2009).

Table 1-1 Chemical composition of the non-volatile fraction of roasted coffee beans.

Component	Content (g/100g dry basis)	
	Coffea Arabica	Coffea Canephora
Carbohydrates and fibers		
Sucrose	4tr-4.2	1tr-1.6
Reducing sugars	0.3	0.3
Polysaccharides (arabinogalactan, mannan, and glucan)	31-33	37
Lignin	3.0	3.0
Pectins	2.0	2.0
Nitrogenous compounds		
Protein	7.5-10	7.5-10
Caffeine	1.1-1.3	2.4-2.5
Trigoneline	0.2-1.2	0.3-0.7
Lipids		
Coffee oil (triglycerides with unsaponifiables)	17.0	11.0
Diterpene esters	0.9	0.2
Minerals	4.5	4.7
Acids and Esters		
Total chlorogenic acids	1.9-2.5	3.3-3.8

Source: Farah, 2009

Physico-chemical characteristics of Coffee

Several factors can influence the final flavor and characteristics of coffee. Some of these factors can be constant and cannot be modified by producers. Some of these constant factors are weather conditions (this factor produces a fluctuation in quality from one season to another), botanical variety, and topographical conditions.

Some factors can be modified by the growers, such as growing conditions, harvesting, storage, export preparation and transport conditions. Coffee cultivation occurs under the following growing conditions: a lot of sunshine, moderate rainfall, altitudes between sea level and 6000 feet, average temperatures between 60 and 70 degrees Fahrenheit, and freedom from frost (Dicum & Luttinger, 1999).

Table 1-2 Classes of volatile compounds identified in roasted coffee

Sulphur Compounds	
	Thiols Hydrogen sulphide Thiophenes (esters, aldehydes, ketones) Thiazoles (alkyl, alcoxy and acetal derivatives)
Pyrazines	 Pyrazine itself Thiol and furfuryl derivatives Alkyl derivatives (primarily methyl and dimethyl)
Pyridines	 *Methyl, ethyl, acetyl and vinyl derivatives*
Pyrroles	 Alkyl, acyl and furfuryl derivatives
Oxazoles Furans	 Aldehydes, ketones, esters, alcohols, acids, thiols, sulfides
Aldehydes and ketones	 Aliphatic and aromatic species
Phenols	

Source: Buffo & Cardelli-Freire, 2004.

According to literature, most of the coffee components are formed after the roasting process. Table 1-2 shows a list of the principal volatile compounds identified in roasted coffee. Green coffee beans contain only a few volatile components. Most of the flavor compounds are first formed during roasting, especially from sucrose, free amino acids, and chlorogenic acid (Steglich & Burkhard Lang-Fugmann, 2000).

The major mechanisms include the Maillard reaction (a reaction between proteins and reducing carbohydrates), Strecker degradation (reaction between an amino acid and α-dicarbonyl), breakdown of Sulphur amino acids (for example, cysteine and methionine), breakdown of hydroxy amino acids, breakdown of proline and hydroxyproline, degradation of trigonelline, quinic acid moiety to form phenols, degradation of pigments, and minor lipid degradation. When the temperature reaches 130 Celsius sucrose starts caramelizing. The browning reactions begin to occur when the temperature is higher, and the color of the coffee beans begin to change from their characteristic light to dark brown. All these changes are essential in the formation of the characteristic roasted aroma and flavor present in coffee (Buffo & Cardelli-Freire, 2004; Nursten, 2005; Steglich & Burkhard Lang-Fugmann, 2000; Farah, 2009).

All these complex reactions will produce the final aroma and flavor present in coffee. Along with the variations in cultivars and other factors, it is easy to understand why coffee is such a complex beverage, and also why there is so much difference between coffees from different origins.

World Coffee Production

Coffee is one of the most popular beverages in the world; it was discovered for the first time in Africa. There are several varieties of coffee, and the most famous ones are Arabica and Robusta. The Arabica variety is native from Ethiopia, and the Robusta variety is indigenous from the Atlantic Coast (specifically Kouilou region and in and around Angola) and the Great Lakes region (International Trade Centre, 2011).

Despite this, most of the world's coffee production is concentrated in Latin America, specifically in Brazil and Colombia. According to the International Trade Centre, in 2011 Brazil was the world's largest grower and seller of coffee, followed by Vietnam in second place, Colombia in third place and Indonesia in fourth place.

According to the literature, coffee is grown in nearly 80 tropical and subtropical countries and is the most valuable item of international trade after petroleum (Dicum & Luttinger, 1999). This fact is an evidence of how important this crop is for the industry; coffee is a sociable and versatile drink that could be consumed during a business meeting or in a familiar scenario visiting coffee shops or during breakfast meetings.

Figure 1-1 shows the largest coffee producers in the world. According to this graphic Brazil produces 34% of world's coffee, followed by Vietnam with 14%. These two countries also export the highest percentage of the world's exports; Brazil exports 31% while Vietnam exports 17% as seen in Figure 1-2.

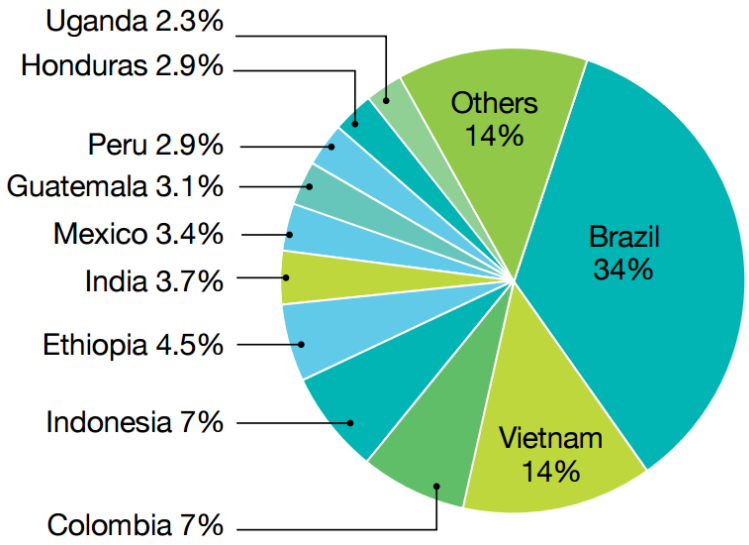

Figure 1-1 Largest producers of coffee as % of global production, 2007-11
(Source: International Coffee Organization, 2015)

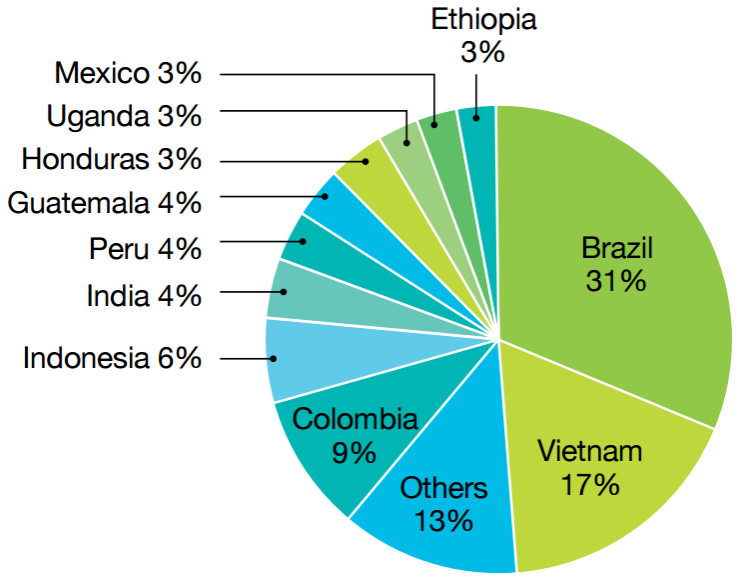

Figure 1-2 Largest exporters of coffee as % of world exports, 2007-11.
(Source: International Coffee Organization, 2015)

According to the International Coffee Organization (2014), the consumption of coffee has increased an annual average of 1.9% over the last 50 years, from 57.9 million bags in 1964 to 142 million bags in 2012. Traditional importing markets are Japan, the European Union, and the USA; they account for the majority of global coffee demand. The United States is the largest coffee consuming nation in the world, drinking roughly one-fifth of the 13.6 billion pounds of coffee grown worldwide (Dicum & Luttinger, 1999).

Processing methods

Coffee is a very complex beverage, and processing methods can affect the final result. For example, the green coffee production, the harvesting procedures, the degree of roasting or even the method used to dry out the seeds could make a difference in the quality of the coffee. Figure 1-3 shows the main procedures that take place during the coffee processing.

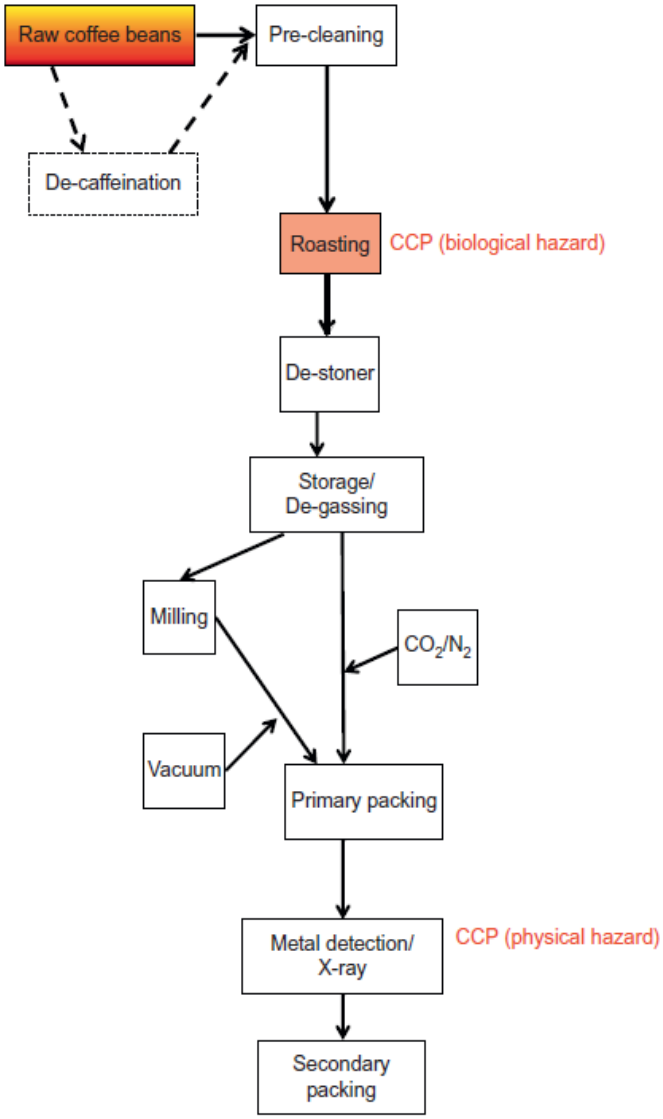

Figure 1-3 Flow Diagram of the general procedures of coffee processing
(Source: Winkler, 2014)

The first critical step in coffee production is harvesting of the crop. During this period, different factors will affect the quality of the coffee fruit. For example, the degree of maturation and the treatment that will be given to the fruit to avoid the plant from being affected by the growth of microorganisms that may be harmful both for the plant and consumers. Fungus contamination and growth during harvesting, drying, and storage of the seeds are critical points during the green coffee production (Farah, 2009).

After the harvesting process, next step is the processing of cherries to extract the coffee seeds. There are two main methods to extract the pulp: the wet and the dry method. During the dry process, the ripe cherries are dried in their entirety after which they are mechanically decorticated to produce the green bean. The drying process could be done by sun drying that is dependent on weather conditions and also will give microorganisms the opportunity to growth. Another possibility is to use a well-controlled mechanical drying machine, this will be more expensive than the sun drying mechanism, but it could be more accurate (Flament & Bessiere-Thomas, 2002; Farah, 2009).

For the washed or wet method usually a first selection of the fruit is made by flotation. Next the ripe fruits are pulped and fermented to remove the coating called mucilage that adheres to the beans, and then the beans are washed and dried. The wet processing tends to generate a higher quality coffee because it has a fermentation period. During this period, the silver skin is removed, the acidity increases and the pH decrease to 4.5. After the wet or the dry method is finished the green bean will be sized and graded to eliminate defective beans, and then the beans are ready for roasting (International Trade Centre, 2011; Farah, 2009).

The roasting process can be controlled by the roasting temperature and time. According to literature, maximum temperatures commonly used in industrial roasters vary between 210 and 230 Celsius. The color of the beans is directly correlated to the final roasting temperature. If the temperature is higher, the coffee beans will be darker. According to the literature, coffee could be described depending on the roasting degree that will be typically described as “light”, “medium” or “dark” (Buffo & Cardelli-Freire, 2004; Farah, 2009).

The Specialty Coffee Association of America (SCAA) created a standard for colorimetric measurements. This system was developed in the early 1990s and is called the Agtron/SCAA

Roast Classification Color Disk System. This system has eight reference points that are matched to eight available color disks with descriptors that go from “Very light brown” to “Very dark brown”. Figure 1-4 shows the different disc that are described in this system, from right to left, the first disc corresponds “Very light brown” (#95) and the last disc corresponds to “Very dark (nearly black) brown” (#25) (Davids, 2010).

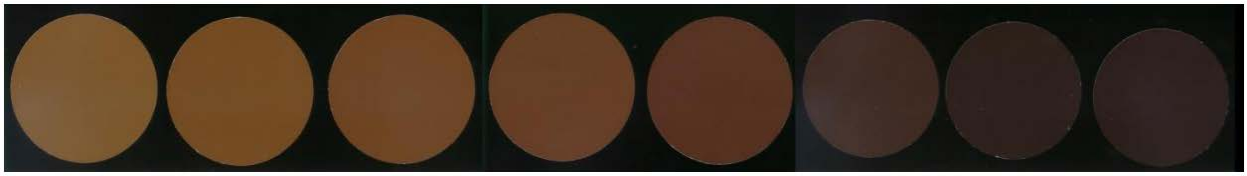

Figure 1-4 Specialty Coffee Association of America (SCAA) Roast Classification Color Disc System.

The level of roasting could also influence the flavor of the coffee. According to Buffo & Cardelli-Freire (2004), roasting time influences the reactions within the bean. For example, longer roasting periods will produce bitter coffee. On the other hand, short roasting periods could result in the insufficient completion of all the reactions that occur during the roasting time, therefore, the coffee flavor may be lower compared to coffees that were roasted for longer periods of time. This is an example of how the processing methods could vary the final flavor and aroma of a cup of coffee.

Brewing Methods

The coffee beans undergo an extraction process with hot water. This process is known as brewing of the coffee beans. According to literature, there are several extraction methods. The most famous ones are decoction methods, infusion methods and pressure methods (Moroney, Lee, O'Brien, Suijver, & Marra, 2015).

All these coffee brewing methods will vary depending on the way they introduce the water into the beans. Several factors will change depending upon the brewing method in use.

Those factors could include the length of time the water stays in contact with the ground coffee, the temperature of the water, the use of pressure to brew the coffee, just to mention a few (Everage, 2004).

The Specialty Coffee Association of America mentioned that typically the brewing process will be divided in three stages: wetting, extraction, and hydrolysis. The SCAA refers the wetting stage to the process in which the ground coffee absorbs the water. The extraction will be identified as the process of exchange of the gasses and volatile compounds present in the wet ground coffee. Finally, the hydrolysis stage will break down the large soluble coffee compounds (Sage, 2015).

Besides the brewing method variations in aroma and flavor can occur due to several different factors. According to the Specialty Coffee Association of America, the industry recognized that transportation, storage, roasting, and packaging, all affect the quality of the final product, which is why it is so important to ensure quality in every one of these stages (SCAA, 2012).

One study comparing coffee extraction methods found that coffee prepared using various espresso methods was stronger in roast and bitter notes than standard or “lunghi” brewing methods and that espresso brews that used less water than standard brewing have fewer chemicals extracted during brewing (Gloess et al., 2013). Those authors also found that standard coffee from automated or semi-automated machines were stronger than other brewing methods.

Lee and Chambers (2009) reported that in green tea, brown and brown-related attributes (ashy/sooty, burnt/scorched), bitterness and astringent become stronger and green and green-related attributes (green beans, spinach) become weaker as the brewing time and water temperature increased.

The initial aroma and flavor of coffee can be described based on the composition of coffee beans, and those unique characteristics derived from the volatile and non-volatile compounds present in the beverage. The instability of some of these compounds explains why the flavor of roasted coffee deteriorates so quickly after the brewing process, as the heat vaporizes these substances into the air, creating that first signal that the coffee is ready to serve (Brown, 1999). In addition, the chemical composition of brewed coffee changes depending extraction method (Caporaso et al., 2014; Gloess et al., 2013).

Coffee Language

Coffee is a very complex beverage that contains several different components. It is for this reason that it is so difficult to find the right vocabulary to describe all the different aromas and flavors present in a cup of coffee. In an article published in 2010 by Davids, there is an explanation of how the language to describe coffee has been changing in the last ten years. Descriptors like medium, dark and heavy were used to describe the degree of roast; now it is common to use more sophisticated terminology that gives detailed information about green coffee descriptors rather than only the roast description.

Several sensory evaluations with consumers and trained panels have been conducted with the purpose of finding the right vocabulary to describe coffee qualities. A study carried out by Narain, Paterson, & Reid (2003), had the purpose of obtaining a consumer vocabulary from free choice profiling of sweetened and unsweetened filter coffee. In this study, they generated a total of 26 attributes for aroma, taste, aftertaste and mouthfeel.

Another study was conducted by Masi et al. (2013) with the aim to describe sensory properties of brews prepared with under-roasted coffees. This was done to explore the development of typical coffee flavor and aroma in milder conditions, different from the standard

roasting treatment. For this study, they found two attribute groups, one group that specifically helped to describe standard roasted coffee, and another for milder samples. The standard roasted samples were described with terms like “burnt” whereas the milder samples were described with terms like “vegetables” and “grain/oats”.

These two studies are just examples of how the use of attributes can help to describe the characteristics present in coffee. In the field of sensory analysis, it is common to use flavor lexicons as tools to help a trained panel to describe these features. This can be done not only in coffee but also in different kinds of foods, beverages or even non-food items.

A flavor lexicon is a set of words to describe the flavor of a product or commodity that will be applied using descriptive analysis techniques. One of the main advantages of using a lexicon is that most of the fully developed lexicons provide attributes, definitions, and references that simplify the use of this vocabulary and its replicability (Lawless & Civille, 2013; Drake & Civille, 2003).

The use of a standardized lexicon can prevent overlap between terms that could occur during tasting when panelists describe a sample, especially for complex beverages like coffee. The use of definitions and references is also helpful since it gives the panel a clear understanding of what the attribute means and how to define the stimuli they perceived from the sample.

A lexicon can be a simple list of attributes use to describe a product or commodity, but it can also be a descriptive document with different levels of complexity. For example in the case of coffee, there could be attributes that need to be used all the time like roasted, bitter, or sour. There are also more specific attributes like blueberry or pineapple that will be used only with special samples that require another level of complexity to be fully described.

Product Controls in Sensory Testing

Product controls in sensory testing is an important topic especially when beverages like coffee are prepared for evaluation. Sample preparation, sample temperature, presentation and the use of correct palate cleansers are critical factors that will affect the sensory characteristics of coffee and also another kind of foods and beverages.

Sample Preparation

There are several things to consider during a sensory testing session, especially related to the sample preparation. According to the literature, if a beverage like coffee is being served, the amount of coffee should be enough to provide at least two sips to the participants in the testing session. There should also be consistency in the protocol that is used during each testing session. For example, the amount of product in each session should be the same each time. The holding time between samples should also be the same, and it should take into consideration any specification of the product that is being served. The holding time is defined as the minimum and maximum time after preparation that a product can be used for a sensory test (Eun Choi, 2014).

Sample preparation is a critical factor when coffee is being prepared. During the brewing stage, water-soluble compounds are extracted, whereas most of the lipophilic fraction is left with the solid material (Farah, 2009). Several factors need to be taken into consideration when preparing coffee samples, especially the grinding size and the brewing method.

Coffee grinding is one of the most important steps in making a good quality cup of coffee. It is preferable to grind the coffee beans immediately before brewing. In that way, it is easier to keep the freshness of the coffee beans and also it is easy to prevent the escape of some of the volatile components. The grind size should match the brew time. Larger grind particles

will require longer brewing time. This way, the water will be able to penetrate all the particles resulting in a good quality cup of coffee (SCAA, 2015).

Figure 1-5 Particle size and its relationship with the brewing time
(Source: SCAA, 2015)

Another important factor to consider is the brewing time; this time will determine how much water will be in contact with the ground coffee. Therefore, the amount of coffee material extracted. As shown in figure 1-5, if the thickness of the ground coffee is fine the brewing time must be reduced. On the other hand, if the ground coffee is thicker the brewing time should be increased (SCAA, 2015).

The time affects the aromas perceived in a cup of coffee. According to literature, longer periods of extraction will lead to undesirable and less soluble components into the final cup of coffee. For example, the attributes rancid and smoke were found in one study during the over-extraction (Modern Process Equipment, 2015).

According to the Specialty Coffee Association of America, the minimum technical requirement is for water contact time with the coffee grounds to be more than four minutes but less than eight minutes. The SCAA also recommends a coffee/water ratio of 55g/1L (this proportion could be adjusted depending on the grind size and contact time) (Specialty Coffee Association of America, 2014).

Sample Temperature

During the evaluation sessions, samples must be presented at the same temperature each time, this temperature should be specified in the test protocol (Eun Choi, 2014). When beverages like coffee are being tested, it is critical to handle the temperature to secure the same sensory experience in each evaluation session. Special equipment can be used to maintain temperature. This equipment could include thermos, water baths or any other equipment or procedure that ensures the right temperature of the beverage.

In the case of coffee, it is important to maintain consistency in the serving temperature because the sensory characteristics of this beverage are temperature dependent. Even a few degrees lower can result in different intensities for certain attributes, in both aroma and flavor. Another beverage that needs special attention in the temperature procedures is tea. Lee et al. (2008), described a method for temperature maintenance of green tea. In their study, they developed a three-step protocol to secure consistency in the temperature of green tea during sensory evaluation. The first step consisted on preheating the infusion flask prior the green tea infusion. Next they used a water bath and finally the samples were poured into an individual thermos to minimize the heat loss during the testing session (Lee, et al., 2008).

Sample temperature is critical since most of the volatility of odors is related to temperature. It is easier to smell hot foods or beverages because only volatile molecules, in the form of gas, can carry odor (Eun Choi, 2014). The SCAA recommends that water temperature at the time it makes contact with coffee grounds should be 92C and never exceed 96C. When performing a testing session, this organization suggests that the brewed coffee should be maintained at a temperature no lower than 80 degrees Celsius and no higher than 85 degrees C during the first thirty minutes of testing (Specialty Coffee Association of America, 2014).

Sample Presentation

To keep consistency in each of the test sessions, the samples should be presented in containers of the same size, color, and shape. White containers are the best option since they could cause less influence on the participants' perceptions of the food's color (Eun Choi, 2014). However, the objective of the study must always be taken into consideration; there are cases where it is important to choose different colors to mask some characteristics of food and beverages that can influence respondent's choices.

For coffee, it is a good idea to present the samples in glasses since this material is the best option to keep the right temperature, and also it is better to avoid any lingering aroma. There are double wall glasses that help to maintain the right temperature and at the same time are comfortable to hold by the panelists. The order of presentation should be randomized, and the samples should be coded with a three digit code. Another thing to consider is how many samples the participants will receive in each session. In beverages like coffee, it is important to consider that too many samples in the same session could cause fatigue and also adaptation and discrimination problems (Briggs, Boulton, Brookes, & Stevens, 2004).

Another point to take into consideration is consistency. It is crucial to develop a protocol at the beginning of the sessions and try to follow the same procedures during all the evaluation sessions. As far as possible the same person should be in charge of preparing the samples, in that way variations due to preparation can be avoided (Kilcast, 2010).

According to the Standard Guide for Serving Protocol for Sensory Evaluation of Foods and Beverages, the sample must be presented in the same utensils and containers all the time during the test (ASTM International, 2010). In this guide, the authors suggest the following recommendations:

1. Before choosing the utensils and containers evaluate the objective of the test.
2. Choose a container that maintains the sample characteristics.
3. Consider the product/container interaction.
4. Consider the amount of sample required to complete the evaluation.
5. The effort required by the assessors to remove the product from the container during the testing session.
6. Containers or utensils should be neutral in appearance (unless a particular color is needed to mask color or other appearance differences) and made of materials that are inert, nonreactive, and odor-free.

The guide recommends doing a pretest before the actual evaluation with the purpose of see if the utensils and containers are the right ones for the study (ASTM International, 2010).

Another important consideration when working with coffee is that during the evaluation sessions the panelists may require extra amounts of the sample because the liquid cools down after a few minutes depending on the kind of containers used during the testing session. The use of thermos to keep the sample at the right temperature is a good idea. In this way, the evaluators can access more sample that will be at the correct temperature.

Palate Cleansers

During a tasting session, it is crucial that panelists have access to adequate palate cleansers. They should use these between samples to avoid fatigue and carryover of smells or flavors. Water should always be present in the tasting room, and other palate cleansers could be used depending on the product that is being tasted. For example, biscuits or bread, cucumber, yogurt, or carrots (Kilcast, 2010).

Plain water, bread, bagels or crackers could be served to participants to eat between samples to prevent carryover tastes. Depending on the product, other types of foods can also be given to respondents. For example, mozzarella cheese, carrots or cucumbers can be used in different samples that tend to produce strong carryover tastes (Eun Choi, 2014).

A few studies have been conducted with the primary purpose of identifying the best palate cleanser options depending on the characteristics of different products. Lee & Vickers (2010), carried out a study with the aim of assessing 6 different palate cleansers and 2 cleansing protocols for their ability to enhance discrimination of tannin-containing and acidic solutions. The six cleansers included water, carboxymethylcellulose, crackers, milk, chewing wax, or nothing. Their results showed that any of the six palate cleanser prevented astringency to build up, they also found that panelists were able to discriminate better among tannin solutions when water or nothing was used as a palate cleanser.

These results were consistent with findings made by Johnson & Vickers, (2003). These authors compared the effectiveness of seven methods used to cleanse the palate when tasting the bitterness of caffeine. The palate cleansers were water, sparkling water, carrots, crackers, and plain cream cheese. They found no differences in the effectiveness of those palate cleansers in their ability to control adaptation and build-up, or their ability to increase participant's discrimination between samples. The only difference they found was that using sparkling water depressed the perception of bitterness at all the different concentrations of caffeine.

Lucak & Delwiche, (2009) conducted a study to evaluate the efficacy of various palate cleansers (table water crackers, whole milk, pectin solution, spring water, warm water and chocolate). In this study coffee was chosen as a representative bitter food, the results showed that spring water and warm water were the only two palate cleansers that allowed significant intensity

changes across replicates. The other palate cleansers (table water crackers, whole milk, pectin solution and chocolate) were consistent between replicates showing efficacy to clean out between coffee samples.

These results are consistent with findings made by Petracco, M., (2005); he suggested that cold whole milk seems to be a good palate cleanser when tasting coffee. The author explained that whole milk is an oil-in-water emulsion, for that reason it can displace coffee oil droplets from the tongue by dilution.

According to all those studies there are several options when deciding which is the best alternative for palate cleansers, however, it is always important to conduct an orientation session with the evaluators and present in this session the possible palate cleansers so they can choose the best option for them based on the product that is being evaluated.

Research objectives

Coffee is a complex beverage, for this reason, it is necessary to have a good vocabulary to describe the characteristics of this drink. Although previous studies have developed coffee terminologies, in most cases they did not use trained panels, had limited sets of samples, or were focused on cultural issues. This project aimed to 1) develop a comprehensive coffee lexicon using a trained sensory panel that allows accurate, repeatable description of a broad range of coffee samples. This lexicon contains clear terminology and references that can be used for future research on coffee, and 2) determine how the preparation method of a widely used product could affect the sensory properties of three different coffees. Four methods of preparation: a consumer coffee maker, an automated espresso machine, “cupping” infusion method and a filtered infusion method were used for this study.

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Chapter 2 - Development of a Coffee Lexicon

ABSTRACT

The objective of this study was to develop a sensory lexicon for coffee. A total of more than 100 different coffee samples from 14 countries around the world were used to create this lexicon. The first list of terms consisted of 74 attributes that were developed from the review of 13 samples from the region of Pitalito, Colombia. A second development incorporated an existing commercial lexicon and examined an additional 92 coffee samples from different parts of the world. Validation sessions were also performed with 20 coffee samples from the area of San Adolfo, Colombia. A highly trained panel from the Sensory Analysis Center (SAC) at Kansas State University (Manhattan, Kansas) assessed the coffee samples using descriptive analysis using a 15-point intensity scale. The sensory panel identified a total of 110 attributes and their references. Principal Component Analysis (PCA) was used to map the scores obtained during the validation phase of the lexicon terminology. For this stage, the coffee lexicon allowed the panelists to describe specific characteristics that were present in the coffee samples such as sweet, nutty and fruity notes, as well as the differentiation of notes such as burnt, smoky, astringent, acrid and bitter. The developed attributes and references were successfully used by the trained panel to describe a broad range of the coffee samples.

Keywords: sensory, lexicon, coffee.

PRACTICAL APPLICATIONS

The terminology that was developed during this study is clear, easy to reproduce in future research and also accompanied by reference standards that provide a guide for future research. This lexicon will provide a valuable tool for the coffee industry allowing to conduct sensory evaluation to improve the understanding of coffee quality.

INTRODUCTION

Coffee is one of the most famous beverages in the world. Its production is an important factor for world's economy according to the International Trade Centre (2011). In 2010 around 97 million 60kg bags of coffee were shipped to different parts of the world. This popular beverage has a high demand worldwide; gross imports quadrupled from 33 million bags in 1949 to 132 million bags in 2010. Coffee is mainly grown in tropical countries because the plant survives in a narrow temperature range that needs to be not too hot either too cold. It grows on a broad range of soil types, and the only requirement is that these soils drain well so the plant can survive torrential rains. According to the literature, the coffee plant originated in Africa and also Madagascar. Literature also suggests that cultivation was first reported in Ethiopia and Yemen (Thurston, Morris & Steiman, 2013; Oestreich-Janzen, 2010).

Coffee includes numerous species, but only two of them are of real economic importance: Arabica and Robusta (Canephora). Coffee Arabica represents the 60-70% of world's production while Robusta represents the 30-40% of world's production (International Trade Centre, 2011). Arabicas tend to be considered of a higher quality than Robustas because of their flavor differences that depend on differences in composition, the amount of sugars and acids present in each variety and the lipid concentration for example. Arabica varieties tend to contain about twice as much sucrose as robustas (Clarke & Vitzthum, 2001).

It is because of those differences in coffee varieties and the effect of processing variables such as fermentation drying, and roasting that it is important to have a lexicon that helps identify the sensory profile of different varieties of coffees from around the world. This vocabulary must be able to offer a broad range of terms for a beverage that has a wide variety of components.

The industry has accepted some common criteria used to define coffee characteristics. This criteria has been used to discuss coffee properties and is mainly divided into two groups: overall characteristics and attributes. The overall characteristics include terms such as fragrance and aroma, acidity, body, flavor, aftertaste and balance. The attributes are descriptors that may not occur in every cup of coffee but when they are present can add complexity and uniqueness to the coffee (Thurston, Morris, & Steiman, 2013).

A few studies have been conducted on the sensory properties of coffee in its various stages, from the green bean to the brewed coffee. For example, studies in Italy (Masi et al. 2013) and Japan (Hayakawa et al., 2010) used descriptive analysis with consumers and untrained coffee professionals to define the sensory properties of brewed coffee and found between 31 to 60 terms that were suggested could be used for coffee. Other studies have used highly-trained sensory panels and focused on certain sensory attributes. For example, Bhumiratana et al., (2011) studied 15 aroma sensory attributes in green and roasted beans, ground coffee, and brewed coffee. They found aroma profiles were more influenced by preparation stage and degree of roasting than variety.

Through a four-step process of collection, description, defining and referencing, and verification Seo, Lee & Hwang (2009) developed a sensory attribute pool of brewed coffee that consisted of 74 terms and indicated that 16 of the terms were unique sensory attributes influenced by the Korean culture.

Although these studies describe different methods for creating a group of sensory attributes, in most cases they did not use trained panels, had limited sets of samples, or were focused on cultural issues in addition to sensory description. Thus, the purpose of this study was to develop a comprehensive coffee lexicon using trained sensory panel containing clear terminology and

references that can be used for future research of varietals, processing, brewing, and other studies of coffee.

MATERIALS AND METHODS

Coffee samples

For the entire process of the coffee lexicon development, a total of 105 coffee samples from 14 different countries were used. These coffees were classified in sets depending on the stage of the coffee lexicon development they were used (Table 2-1). A first set of 13 Arabica samples from the region of Pitalito, Colombia were used. Set 2 included 45 coffees (Arabica, Robusta, and blends), set 3 included 27 specialty coffees samples (Arabica) from different parts of the world and set 4 included 20 Arabica coffee samples from San Adolfo, Colombia. Appendix A details each sample along with their specifications.

After each stage, the samples were transferred to Food Saver vacuum seal bags. The coffee beans were vacuum sealed using a Food Saver Heat-Seal Vacuum Sealing System (Sunbeam Products Inc., Boca Raton, FL, USA) and were stored under frozen conditions (-26C).

Table 2-1 Coffee Samples used in the development of the lexicon

Coffee Samples	Country	Number of Samples
Set 1: (Single Varietal, Various growing conditions)	Colombia	13
Set 2: Purchased Commercial Samples (Multi Varietal)	Indonesia, USA, Ethiopia, Guatemala, Kenya, Papua New Guinea, Colombia, India, Thailand, Vietnam, includes coffees from unknown origins	45

Set 3: Donated Commercial Samples (single varietals and micro-lot coffees)	Brazil, Guatemala, Mexico, Ethiopia, Kenya, Costa Rica, Indonesia	27
Set 4: (Multi Varietal)	Colombia	20

Sample preparation

The coffee samples used in this study were labeled with three-digit codes. An amount of 4oz was served to the panelists in 6oz double wall glasses for their assessment. Different brewing methods were used to prepare the coffee samples depending on the coffee sets:

Sets 1 and 4

Filtered infusion method: The amount of coffee sample evaluated was determined at 5.5g per 100mL of water. This ratio is in accordance with the International Standard for the preparation of coffee samples for use in sensory analysis that suggests a ratio in a 5–9 g range per 100 mL of water (ISO 6668:2008).

Sets 2 and 3

Consumer drip coffee maker: a General Electric Coffee Maker Machine (Model 169058, Capacity 12 cups. General Electric (GE), NY, USA) was used to brew the coffee at 5.5g per 100mL of water. For this method, Melitta Cone Coffee Filter No. 4 (Melitta USA, Inc., Clearwater, FL, USA) were used for the preparation of the samples.

Automated espresso machine: A few samples from sets 3 and 4 were also prepared in an automated espresso machine brand La Marzocco, model GS-3 (La Marzocco International LLC., Seattle, WA, USA). Each sample was prepared individually, and the machine took around 15 to 25 seconds to prepare each sample at a ratio of 6g per 60mL of water at approximately 9 bars. The temperature of the water was between 93.8 F to 94.3 F.

For each of the sets, the coffee beans were ground no more than 30 min before the brewing using a grinder machine Baratza Forté BG (Baratza LLC, Bellevue, WA, USA).

Panel

The sensory panel consisted of five highly trained panelists from the Sensory Analysis Center (SAC) at Kansas State University (Manhattan, Kansas) (one male and four females; age range 50-70 years). The panelists' experience included 120 hours of general descriptive analysis training and a minimum of 2000 hours of general sensory testing of beverages and food products. All had previously tested coffee. For this project, the panelists received further orientation to coffee using samples that may or may not be included in the study. In addition, a coffee training was held by a coffee training consultant from Sensory Spectrum™ with the purpose of increasing panelist's experience in coffee tasting. In total more than 50 hours of training was conducted.

Development and Testing

The trained panel went through a first phase where they had to taste the coffee samples from set 1 and determine the procedures to evaluate these samples. References were shown to the trained panel to help them to find the appropriate intensities for those references. Some of the definitions and references were proposed by the group of panelists. Researchers also proposed other terms based on previous experience work, and literature was consulted to include more terms that had been used in previous sensory research (Bhumiratana, Adhikari & Chambers, 2011; Hayakawa, et al., 2010; Narain, Paterson & Reid, 2003). The panel was informed about the objective of the orientation and lexicon sessions, the attributes that came up after these sessions were evaluated on a 15 point scale to give intensities to the different references that were used to describe those attributes.

Throughout the process of the lexicon development, the panelists used a consensus process to determine the attributes, the definitions, references, and scores for those references. That technique has been used commonly in lexicon development (Ting, et al., 2015; Pereira, et al., 2015; Cherdchu and Chambers, 2015; Heymann et al., 2014). According to the literature, to generate a lexicon it is necessary to collect a product frame of reference, generate the terms, review references and examples and finally develop a final descriptor list. Based on these steps the process to develop the coffee lexicon began with daily 1.5 h sessions during a month. Each of these sessions was destined to different activities like establish, discuss and refine the lexicon attributes, definitions, and references to avoid redundant information and overlapping descriptive terms (Drake and Civille, 2003; Lawless and Civille, 2013).

Panelists were asked to develop terms not exclusively belonging to the samples that were shown but potentially to the wider coffee category based on their previous experiences and work on samples showed during the lexicon development phase.

The evaluation of the coffee samples begun with the aroma, then flavor, and finally aftertaste (attributes for texture and amplitude were included in the final list of attributes of this lexicon based on further training). For aroma evaluation, each panelist lifted the watch glass of a snifter and took 3 to 4 short sniffs to detect the smells that were present on the coffee samples. Next, panelists took a sip of the samples to evaluate flavor. Finally, they wait 15 seconds to determine aftertaste. For each group of attributes that was proposed, references were introduced and then modified until each of the participants agreed with these references.

The panelists rinsed their mouths with water between samples and also had crackers, bagels and apples to clean their palate, if needed. For some of the sessions, they breathed through a warm, clean, cotton terry cloth filter to clean their nasal passages.

The coffee samples from set 2 were used for a coffee training that was held by a consultant from Sensory Spectrum™. The training consisted of 5 sessions of 2.5 hours, in these sessions the panelists were able to practice with references from an existing commercial lexicon. After the five sessions new attributes and references were added to the original lexicon.

Further practice sessions were held with the coffee samples from set 3. For these training sessions, a group of acids were added to the coffee lexicon after the panelist's discussions. This group of acids were isovaleric, butyric, acetic, and malic. Further discussion from the panelists and researchers also lead to the addition of extra attributes that were found in the group of coffee samples present in this set. Also based on discussion from the panelists and researchers, a few attribute's names were changed to make them easier to interpret.

Descriptive analysis of some coffee samples to validate the lexicon

Six highly trained panelists from the Sensory Analysis Center participated in the tasting sessions of 20 coffee samples (set 4). These samples were scored by the trained panel using the coffee lexicon to validate the attributes and references. From the complete list of attributes of the lexicon, the panel chose the 50 terms they considered were present in those coffee samples. A statistical analysis was conducted using SAS (Version 9.2, SAS Institute, Inc., Cary, NC) to calculate the analysis of variance with the panel measures in three replications. Fisher's least significant difference test was utilized with a confidence level of 95%. The scores of the statistically significant attributes were mapped using Principal Components Analysis (PCA) to determine how useful the developed terms were in explaining the diverse characteristics present in each of the samples.

RESULTS AND DISCUSSION

More than 100 coffee samples were tasted in order to develop a coffee lexicon. This document went through several reviews before concluding with a total of 110 attributes and references. A first phase with the coffee samples from set 1 was conducted by the trained panel, the initial terms and categories are detailed in Table 2-2. A total of a 74 attributes were developed. This first list included most of the commonly found characteristics in coffee and some unique notes only found in one or a few coffee samples.

Table 2-2 Initial list of lexicon terms generated by the descriptive panel from Set 1

Attributes				
Roasted	Malt	Vanilla	Chocolate	Overripe/near fermented
Burnt	Brown	Vanillin	Floral	Sour aromatics
Acrid	Spice Brown: Nutmeg Clove Cinnamon	Honey	Fruity	Green: Peapods Herb-like Hay-like
Smoky	Pepper	Syrup (maple)	Fruity-Dark: Prune Raisins	Raw
Ashy	Pungent	Molasses	Fruity, Citrus: Lemon Lime Grapefruit Orange	Beany
Woody	Sweet Aromatics	Nutty	Fruity, berry: Blackberry Raspberry Blueberry Strawberry	Tobacco
Grain	Brown Sweet: Caramelized	Cocoa	Fruity, non-citrus: Grape Cherry Peach Pear Apple	Fermented
Alcohol Whiskey	Musty: Dusty	Phenolic	Stale	Cardboard

Cordial	Earthy Damp			
Rubber Like	Petroleum Like	Medicinal	Astringent	Metallic
Bitter	Sour	Sweet		

The initial list of terms were defined by the consensus technique, each of the attributes had a group of references that represent the high, medium, and/or low intensity in the 15-point scale used to evaluate the coffee samples in set 1.

The second phase consisted of examining 45 coffee samples from set 2 (Table 2-1). This phase was part of a training held by a consultant from Sensory Spectrum™. For this training, the panel reviewed a commercial lexicon in order to explore additional attributes that could be included in the lexicon. They also received training sessions related to basic tastes and coffee roasting. At the end of this training, a list of 7 attributes and alternative references were included in the coffee lexicon: green vegetative, green fresh, cigar tobacco, meaty-brothy, fermented-winey, papery and skunky.

An additional session was held to further evaluate and add references from the 27 additional Arabica and Robusta samples from various parts of the world (set 3 from Table 2-1). During these lexicon development sessions, panelists were asked not to focus on existing attributes in the lexicon, but to taste the coffee samples and write down new attributes for aroma, flavor and aftertaste, and also they were asked to explore attributes for texture and amplitude.

Once a consensus was reached that a new attribute needed to be included in the lexicon, references were suggested and intensities were given. For aroma 19 attributes were added: hazelnut, almond, peanuts, dark chocolate, rose, jasmine, chamomile, pomegranate, pineapple, coconut, olive oil, green under-ripe, dark green, pipe tobacco, black tea, animalic, butyric acid, isovaleric acid, and malic acid. For flavor 12 attributes were added: overall sweet, hazelnut,

almond, peanuts, dark chocolate, chamomile, pomegranate, pineapple, green vegetative, dark green, black tea, salty. In addition, 5 attributes were added for amplitude (overall impact, balance-blended, longevity, fullness, and fidelity) and 3 for texture (mouth drying, viscosity, and oily).

During this third phase a few terms were added, and also some references were changed or modified to better describe each of the attributes. For example, for the term “nutty”, a combination of almonds and hazelnuts were initially used as a reference. However, the panelists often found a slight rancid note in the hazelnuts and the reference was changed to a blend of almonds and walnuts, which gave a closer match to the overall “nutty” character.

Another example occurred with the attributes “roasted” and “bitter”, these two attributes had added additional references to enhance understanding of the scale and to provide a more specific determination of the intensities. Whenever references were changed or added, the trained panel reviewed the intensity of the new reference to readjust the right intensity.

Attributes such as “roasted” were modified to ensure that they were focused more on the intensity of roast character rather than the degree of roast. This is important because dark roast is not a high level of roast, but a separate characteristics.

After the three phases of the coffee lexicon development, a total of 110 attributes with their respective definitions and references was developed. This final list is shown in Table 2-3.

Table 2-3 List of attributes and references for the Coffee Lexicon

Sensory Attribute	Definition	References and intensities*
Roasted	Dark brown impression characteristic of products cooked to a high temperature by dry heat. Does not include bitter or burnt notes. Dark brown impression characteristic of products cooked to a high temperature by dry heat. Does not include bitter or burnt notes.	Aroma/Flavor Le Nez du café` n. 34 'roasted coffee': 7.5(a) Lightly roasted peanuts = 2.5 (f) Medium roasted peanuts = 6.5 (f) Dark roasted peanuts = 9.5 (f) Over roasted peanuts = 15.0 (f)
Raw	Aromatics associated with uncooked products.	Flavor Fisher Whole Natural Almonds = 3.0
Burnt	The dark brown impression of an over-cooked or over-roasted product that can be sharp, bitter and sour.	Aroma/Flavor Benzyl disulfide = 4.5 (a) Alf's Red Wheat Puffs (2 pieces in the mouth) = 8.0 (a), 3.0 (f) Over Roasted Peanuts/Burnt =7.5 (f)
Acrid	The sharp, pungent, bitter, acidic aromatics associated with products that are excessively roasted or browned.	Aroma/Flavor Alf's Red Wheat Puffs = 3.0 (a), 3.0 (f) Wright's Liquid Smoke = 9.5 (a)
Smoky	An acute pungent aromatic that is a product of combustion of wood, leaves or non-natural product.	Aroma/Flavor Benzyl disulfide = 3.5 (a) Wood Ashes = 5.0 (a) Diamond Smoked Almonds = 6.0 (a), 5.0 (f)
Ashy	Dry, dusty, dirty smoky aromatics associated with the residual of burnt products.	Aroma/Flavor Benzyl disulfide = 4.0 (a) Paper ashes = 4.0 (a) Gerkens Midnight Black (BL80) cocoa Powder = 2.5 (a), 3.5(f)
Brown, roast	A rich, full round, aromatic impression always characterized as some degree of darkness generally associated with attributes such as toasted nutty, roasted, sweet.	Aroma/Flavor Bush Pinto Beans (canned) = 6.0 (a), 3.0 (f) C&H Golden brown sugar = 3.0 (a), 7.0 (f)

Woody	The sweet, brown, musty, dark aromatics associated with a bark of a tree.	Aroma/Flavor Diamond Shelled Walnuts = 4.0 (a), 4.0(f) Popsicle sticks = 7.5 (a)
Grain	Light brown, dusty, musty, sweet aromatics associated with grains.	Aroma/Flavor Cereal Mix (dry) = 5.0 (a), 8.0 (f)
Malt	Light brown, dusty, musty, sweet, sour and or slightly fermented aromatics associated with grains.	Aroma/Flavor Post Grape Nuts Cereal = 3.5(a), 8.0(f)
Spices/Pungent[a]	The sharp physically penetrating sensation in the nasal cavity.	Aroma Majestic Mountain Sage Orange, Brazil Essential Oil = 5.0
Spices/Spice Brown[a]	Sweet, brown aromatics associated with spices such as cinnamon, clove, nutmeg, allspice.	Aroma/Flavor Private Selection cinnamon sticks = 3.0 Private Selection Nutmeg / Clove = 7.0 Spice brown complex = 10.5 (a), 10.5 (f)
Spice Brown/Nutmeg[b]	Sweet, brown, woody, pungent, petroleum like heavy aromatic with a slightly lemony impression.	Aroma McCormick ground nutmeg = 9.0
Spice Brown/Clove[b]	A sweet, brown spicy, pungent, floral, citrus, medicinal, and slightly minty aromatic.	Aroma Le Nez du café` 'clove' n.7 = 6.5
Spice Brown/Cinnamon[b]	A sweet, brown, slightly woody, slightly pungent, spicy aromatic.	Aroma McCormick cinnamon = 13.0
Spices/Pepper[a]	Spicy, pungent, musty and woody aromatics characteristic of ground black pepper.	Aroma McCormick Ground Black Pepper = 13.0
Spices/Anise[a]	A pungent, sweet, brown, caramelized aromatic that may contain petroleum, medicinal, and floral notes.	Aroma Tone's Pure Anise extract: 7.5
Sweet	A fundamental taste factor of which sucrose is typical.	Flavor 1% Sucrose Solution = 1.0
Honey	Sweet, light brown, slightly spicy aromatics associated with honey.	Aroma/Flavor Busy Bee Honey in water = 6.0 (a), 6.5 (f)
Maple Syrup	A woody, sweet, caramelized, brown, slightly green aromatic associated with maple syrup.	Aroma/Flavor Le nez du café Maple Syrup essence (n.24) = 7.0 (a) Maple Grove Farms Pure Maple Syrup = 5.0 (f)

Molasses	Dark caramelized top notes which may include slightly sharp, acrid and sulfur notes characteristic of molasses.	Aroma/Flavor Grandma's molasses = 6.5 (a), 6.5 (f)
Sweet Aromatics	An aromatic associated with the impression of a sweet substance.	Aroma/Flavor Fisher Scientific Vanillin in water (0.5g/250ml) = 5.0 (a) Fisher Scientific Vanillin in water (2 g/250ml) = 7.0 (a) Nabisco Lorna Done Cookies = 5.0 (f)
Sweet Aromatics/Overall Sweet[a]	The perception of a combination of sweet taste and aromatics.	Flavor Post Shredded Wheat 1.5 General Mills Wheaties = 3.0 Nabisco Lorna Doone Cookies 5.0
Sweet Aromatics/Brown Sugar[a]	A rich, full round sweet aromatic impression characterized by some degree of darkness.	Aroma/Flavor C&H Golden brown sugar = 6.0 (a) C&H Golden brown sugar in water = 5.0 (f)
Brown Sugar/Caramelized[b]	A round full bodied medium brown sweet aromatic associated with cooked sugars and other carbohydrates. Does not include burnt or scorched notes.	Aroma/Flavor Le Nez du café` n. 25 'caramel' = 8.0 (a) 6% C&H Golden brown sugar solution in water = 4.5 (f) C&H Golden brown sugar in water = 2.5 (f) Caramelized sugar = 7.5 (f)
Sweet Aromatics/Vanilla[a]	A woody, slightly chemical aromatic associated with vanilla bean which may include brown, beany, floral, and spicy.	Aroma/Flavor Le nez du café` Vanilla (n.10) essence = 2.5 (a) Spice Island Bourbon Vanilla Bean= 5.5 (a) McCormick pure vanilla extract in Hiland whole milk = 3.0 (f)
Sweet Aromatics/Vanillin[a]	An extremely sweet non-natural aromatic often associated with vanilla, cotton candy, and marshmallows.	Aroma Fisher Scientific Vanillin in water (2 g/250ml)
Nutty	A combination of slightly sweet, brown, woody, oily, musty, astringent, and bitter aromatics commonly associated with nuts, seeds, beans, and grains.	Aroma/Flavor Le Nez du café n. 29 'roasted hazelnuts' = 7.5(a) Mixture of Diamond Sliced Almonds and Diamond Shelled Walnuts = 7.5 (f)

Nutty/Hazelnut[a]	A woody, brown, sweet, musty/earthy, slightly cedar aromatic. May include floral, beany, oily, astringent, bitter flavor notes.	Aroma/Flavor 1/8 tsp McCormick Imitation Hazelnut extract in 1 cup whole milk= 3.5 (f) ¼ tsp McCormick Imitation Hazelnut extract in 1 cup whole milk = 6.0 (f) Le Nez du café n. 29 'roasted hazelnuts' = 5.5 (a)
Nutty/Almond[a]	A sweet light brown, woody, buttery, aromatic with floral/fruity notes which may include rose, cherry, and apricot. It is also astringent and may slightly smoky.	Aroma Le Nez du Café n.27 'roasted almonds' = 7.0
Nutty/Peanuts[a]	A sweet, light brown, oily, somewhat musty/dusty, beany aromatic which may be slightly astringent.	Aroma/Flavor Roasted peanuts (shelled blanched peanuts from bulk) = 7.5 (f), 8.5 (a)
Cocoa	A brown, sweet, dusty, musty, often bitter aromatic associated with cocoa bean, powdered cocoa, and chocolate bars.	Aroma/Flavor Hershey's Cocoa Powder in water = 7.5 (a), 5.0 (f)
Chocolate	A blend of cocoa including cocoa butter and dark roast aromatics at varying intensities.	Aroma/Flavor Nestle` Semi-sweet chocolate chips (taste 1 chip) = 8.0 (a), 7.5 (f)
Chocolate/Dark Chocolate[a]	A high-intensity blend of cocoa and cocoa butter that may include dark roast, spicy, burnt, must notes which include increased astringency and bitterness.	Aroma/Flavor Lindt Excellence Dark Chocolate bar 90% cocoa: 6.0 (a), 11.0 (f) Dove dark chocolate = 8.5 (f)
Floral	Sweet, light, slightly fragrant aromatic associated with (*fresh*) flowers.	Aroma/Flavor Diluted Welch's White Grape juice, diluted 1:1 = 6.0 (f), 5.0 (a) Carnation essence oil: 7.5 (a) Le Nez du café` n.12 'coffee blossom' = 8.0 (a)
Floral/Rose[a]	A sweet, soft, slightly musty/dusty floral fragrance associated with fresh or dried roses.	Aroma Rose water = 5.0
Floral/Jasmine[a]	An intense, slightly pungent, sweet, floral aromatic with underlying green, musty/ dusty notes.	Aroma Jasmine extract = 8.5

Floral/Chamomile[a]	Sweet, slightly floral/ fruity somewhat woody, green associated with chamomile.	Aroma/Flavor Celestial Chamomile tea (brewed) = 5.0 (a) 5.0 (f)
Fruity	A sweet, floral aromatic blend of a variety of ripe fruits.	Aroma/Flavor Juicy Juice Nestle All Natural 100% Kiwi Strawberry diluted (1:1) = 4.0 (f), 3.0 (a) Le Nez du café n.17 'Apple' = 7.0 (a)
Fruity/Dried Fruit[a]	An aromatic impression of dried fruit that is sweet and slightly brown associated with dried plums and raisins.	Aroma/Flavor Diluted Sunsweet prune juice = 3.0 (a), 4.5 (f) 1/4 cup Sun-Maid raisins and 1/4 cup of Sun Maid prunes (chopped), 3/4 cup of water = 5.0 (a), 6.0 (f),
Dried Fruit/Prune[b]	The aromatic impression of dark fruit associated with dried plums that are sweet, slightly brown, floral, musty and overripe.	Aroma/Flavor 1/2 cup of Sun Maid prunes (chopped), 3/4 cup of water = 4.5 (a), 5.0 (f)
Dried Fruit/Raisins[b]	The concentrated sweet, somewhat sour, brown, fruity, floral aromatic characteristic of dried grapes.	Aroma/Flavor 1/2 cup Sun Maid raisins (chopped), 3/4 water = 6.0 (a), 5.5 (f)
Fruity/Citrus Fruit[a]	The citric, sour, astringent, slightly sweet, peely, and somewhat floral aromatics which may include lemons, limes, grapefruits, and oranges.	Aroma/Flavor Peels of lemon and lime = 4.5 (a) Grapefruit peel = 7.5 (a) Five Alive Frozen Concentrate = 6.5 (f)
Citrus Fruit/Lemon[b]	The citric, sour, astringent, slightly sweet, peely and somewhat floral aromatics associated with lemon.	Aroma/Flavor Fresh lemon juice = 5.0 (a), Fresh lemon juice in water (1:4) = 7.0 (f) Le Nez du café n.15 'lemon' = 5.5 (a)
Citrus Fruit/Lime[b]	The citric, sour, astringent, bitter, green, peely, sharp and somewhat floral aromatics associated with limes.	Aroma/Flavor Lime peel: 6.5 (a) Rea Lime 100% Lime Juice = 7.0 (f)
Citrus Fruit/Grapefruit[b]	The citric sour, bitter, astringent, peely, sharp, slightly sweet aromatics associated with grapefruit.	Flavor Kroger 100% White Grapefruit Juice= 13.5 (f)

Citrus Fruit/Orange[b]	The citric, sweet, floral, slightly sour aromatic associated with oranges, may include bitter, peely and astringent notes.	Flavor Orange juice Tropicana Pure premium, "Oxygen", no pulp = 10.0 (f)
Fruity/Berry[a]	The sweet, sour, floral, sometimes heavy aromatic associated with a variety of berries such as blackberries, raspberries, blueberries, strawberries.	Aroma/Flavor Private Selection Triple Berry = 9.0 (f), 10.0 (a) *Welch's Farmers Pick Blackberry juice = 7.5 (f)*
Berry/Blackberry[b]	Sweet, dark, fruity, floral, slightly sour, somewhat woody aromatics associated with blackberry.	Flavor Smuckers Blackberry Jam = 5.5
Berry/Raspberry[b]	Light sweet, fruity, floral, slightly sour and musty aromatics associated with raspberries.	Flavor Jell-O Raspberry Gelatin (dry) = 6.5
Berry/Blueberry[b]	Slightly dark, fruity, sweet, slightly sour, musty, dusty, floral aromatics associated with blueberry.	Aroma/Flavor Oregon Blueberries in light syrup canned juice = 6.5 (a) Oregon Blueberries canned = 6.0 (f) Oregon Blueberries in light syrup canned = 6.0 (f)
Berry/Strawberry[b]	Somewhat sweet, slightly sour, floral, fruity, frequently viney aromatics associated with strawberry.	Aroma/Flavor Chandler Frozen Strawberries =13(a), 6.0 (f)
Fruity/Stone Fruit[a]	A sweet, light fruity, somewhat floral, sour, or green aromatics which may include – apples, grapes, peaches, pears, cherry.	Aroma Le Nez du café n.17 'Apple' = 7.0 (a)
Stone Fruit/Peach[b]	The floral perfuming, fruity, sweet, slightly sour aromatics associated with peaches.	Aroma/Flavor Fresh Peach Pit = 8.0 (a) Jell-O Peach Gelatin (dry) =7.0 (f)
Stone Fruit/Pear[b]	The sweet, slightly floral, musty, woody, fruity, aromatics associated with pears.	Flavor Jumex Pear Nectar - can = 7.5
Stone Fruit/Apple[b]	A sweet, light, fruity, somewhat floral, aromatic commonly associated with fresh or processed apples.	Aroma/Flavor Le Nez du café n.17 'Apple' = 5.0 (a) Gerber Apple sauce = 6.0(f)
Stone Fruit/Pomegranate[b]	Sour, sweet fruity aromatics that may be somewhat dark, musty and earthy, reminiscent of dark fruits, and root vegetables such as beets and carrots; may also have an astringent mouthfeel.	Aroma/Flavor KNUDSEN Organic Just Pomegranate Juice = 5.5 (a), 7.5 (f);

Stone Fruit/Grape[b]	The sweet fruity, floral, slightly sour, musty aromatics commonly associated with grapes.	Flavor Welch's Concord Grape Juice diluted (1:1) = 5.0
Stone Fruit/Cherry[b]	The sour fruity, slightly bitter, floral aromatics associated with cherries.	Flavor RW Knudsen Cherry Juice diluted = 4.0
Tropical Fruit/Pineapple[b]	Sweet, slightly sharp fruit aromatic associated with pineapple.	Aroma/Flavor Dole pineapple juice diluted (1:1)= 6.5 (a) 6.0 (f)
Tropical Fruit/Coconut[b]	Slightly sweet, nutty, somewhat woody aromatic associated with coconut.	Aroma Coconut imitation extract = 7.5 (a)
Over-ripe	An aromatic of fruit or vegetable past their optimum ripeness which may include sweet, slightly sour, damp, musty earthy characteristics.	Aroma/Flavor Overripe banana (1 week not refrigerated): 6.5 (a), 6.5 (f)
Fermented	Pungent, sweet, slightly sour, sometimes yeasty, alcohol like aromatics characteristics of fermented fruits or sugar or over-proofed dough.	Aroma Guinness Dark Stout beer = 5.0 Blackberry WONF 3RA654 (drop on cotton ball) = 7.0 Silage = 7.0
Sour Aromatics	An aromatic associated with the impression of a sour product.	Aroma Bush Pinto Beans (canned) = 2.0
Olive Oil	A light oily aromatic which may have buttery, green, peppery, bitter, and sweet aromatics.	Aroma Bertolli Extra Virgin Olive Oil: 8.5
Green	Aromatic characteristic of fresh plant-based material. Attributes may include leafy, viney, unripe, grassy, peapod.	Aroma/Flavor Parsley water= 9.0 (a), 6.0 (f)
Green/Under-ripe[a]	An aromatic found in green/under-ripe fruit.	Aroma Grapefruit peel: 7.5
Green/Peapod[a]	Green aromatics that include sweet, beany, fresh, raw, musty/earthy.	Aroma Le nez du café` n. 3 'Garden peas' = 7.0
Green/Herb-like[a]	The aromatic common associated with green herbs that may be characterized as sweet, slightly pungent, slightly bitter, and may or may not include green or brown notes.	Aroma/Flavor Mixture of McCormick bay leaves, McCormick ground thyme, and McCormick basil = 6.0 (a), 5.0(f)
Green/Hay-like[a]	Slightly sweet dry dusty aromatic with a slight green character associated with dry grasses.	Aroma/Flavor McCormick parsley Flakes = 7.5 (a), 7.5 (f)

Green/Vegetative[a]	Sharp slightly pungent aromatics associated with green/plant/vegetable matter such as parsley, spinach, pea pod, etc.	Flavor Green Giant Canned asparagus = 6.0
Green/Fresh[a]	A green aromatics associated with newly cut grass and leafy plants; characterized by sweet and pungent character.	Aroma Fresh green grass = 7.0
Green/Dark Green[a]	The aromatics commonly associated with cooked green vegetables such as spinach, kale, green beans that may include bitter, sweet, dusty, musty, earthy, and may have a dark heavy impression.	Aroma/Flavor Green giant Green beans water: 5.0 (a), 6.0 (f) Del Monte Leaf Spinach water: 7.0 (a), 6.0 (f)
Beany	Aromatic characteristic of beans and bean products includes musty/earthy, musty/dusty, sour aromatics, bitter aromatics, starchy and green/pea pod, nutty or brown.	Aroma/Flavor Bush Pinto Beans (canned) = 7.0 (a), 7.5 (f)
Tobacco	The brown, slightly sweet, slightly pungent aromatic associated with cured tobacco.	Aroma Le Nez du café` n. 33 'pipe tobacco' = 5.0 Camel cigarettes (Turkish and Domestic blend) = 7.0
Tobacco/Cigar[a]	The aromatics associated with cigar tobacco.	Aroma Cigar tobacco = 10.5 Unscented pipe tobacco = 10.5
Tobacco/Pipe[a]	The brown, sweet, slightly pungent, fruity, floral, spicy aromatics associated with cured tobacco.	Aroma Carter Hall Pipe Tobacco: 6.5
Tobacco/Black Tea[a]	Green tea leaves that have been oxidized, or fermented, imparting a characteristic reddish brew.	Aroma/Flavor Lipton black tea leaves = 8.0 (a) Lipton Black tea (brewed) = 7.0 (f)
Animal/Animalic[a]	A combination of aromatics associated with farm animals and lives animal habitation.	Aroma Unflavored gelatin = 3.0
Animal/Meaty-Brothy[a]	The aromatic associated with boiled meat, soup, or stock. Weak meaty notes.	Flavor Campbell's beef broth = 9.5
Alcohol	A colorless pungent chemical-like aromatics associated with distilled spirits or grain products.	Aroma Absolute Vodka 80 Proof = 5.0
Alcohol/Whiskey[a]	Aromatics associated with distilled products from fermented grain mash.	Aroma Jack Daniel's Whiskey Old No.7 = 5.5 (a)

Alcohol/Winey[a]	Sharp, pungent, somewhat fruity alcohol-like aromatic associated with wine.	Flavor Yellow Tail Cabernet Sauvignon = 10.0
Musty/Dusty[a]	The aromatics associated with dry closed air spaces such as attics and closets. May be dry, musty, papery, dry soil or grain.	Aroma Kretschmer Wheat Germ = 5.0 2, 3, 4 – Trimethoxybenzaldehyde = 10.0
Musty/Earthy[a]	Somewhat sweet, heavy aromatics associated with decaying vegetation and damp black soil.	Aroma Miracle Soil Potting soil = 9.0 Le Nez du café` n.1 'earthy' = 12.0
Musty/Moldy-Damp[a]	The aromatics associated with damp closed spaces or basements. May be musty, sharp, and slightly green.	Aroma 2-Ethyl-1-Hexanol 10,000 ppm = 6.0 (a) 2,3,5,6 – Tetrachloroanisole = 10.0 (a)
Musty/Phenolic[a]	The aromatic described as damp, musty, and like animal hide. Reminiscent of a tack room.	Aroma Phenyl acetic acid = 6.0
Stale	The aromatics characterized by lack of freshness.	Aroma/Flavor Mama Mary's Pizza Crust = 4.5 (a), 4.0 (f)
Papery	The aromatics associated with white paper cups.	Flavor Pure Brew Coffee Filters = 2.5 (f)
Cardboard	The aromatic associated with cardboard or paper packaging.	Aroma Cardboard = 7.5
Chemical/Rubber[a]	A dark heavy slightly sharp and pungent aromatic associated with rubber.	Aroma A&W Rubber bands = 5.0
Chemical/Petroleum[a]	A specific chemical aromatic associated with crude oil and its refined products that have heavy oil characteristics.	Aroma Vaseline Petroleum Jelly: 3.0
Chemical/Medicinal[a]	A clean, sterile aromatic characteristic of antiseptic-like products such as Band-Aids, alcohol, and iodine.	Aroma Le Nez du café n. 35 'medicinal' = 6.0 Johnson & Johnson Band-Aid adhesive Bandage (2.5 x 7.6 cm size) = 6.0
Chemical/Skunky[a]	A combination of aromatics associated with skunks. Somewhat like the aroma of urine.	Aroma/Flavor Latex Balloon = 2.5 (a)
Metallic	An aromatic and mouthfeel associated with tin cans or aluminum foil.	Flavor 0.10% Potassium Chloride Solution = 1.5

Bitter	The fundamental taste factor associated with a caffeine solution.	Flavor 0.02% Caffeine Solution = 3.5 0.035 % Caffeine Solution = 5.0 0.05% Caffeine solution = 6.5 0.06% Caffeine solution = 8.5 0.07% Caffeine solution = 10.0 0.1 % Caffeine solution = 12.0
Sour	The fundamental taste factor associated with a citric acid solution.	Flavor 0.015% Citric Acid Solution = 1.5 0.05% Citric Acid Solution = 3.5
Salty	A fundamental taste factor of which sodium chloride is typical.	Flavor 0.15% Sodium Chloride Solution = 1.5
Butyric Acid	A sour, fermented dairy aromatic associated with certain aged cheeses such as parmesan.	Aroma/Flavor 0.4 µl/l Butyric acid solution = 2.5 (a) 3.0 (f)
Isovaleric Acid	A pungent, sour aromatic associated with sweaty, perspiration generated foot odor and certain aged cheeses such as Romano.	Aroma/Flavor 0.2 µl/l Isovaleric acid solution = 3.0 (a) 4.0 (f)
Malic Acid	A sour, sharp somewhat fruity aromatic accompanied by astringency.	Flavor 0.5 g/ l malic acid solution = 3.0 1 g/l malic acid solution= 5.0
Acetic Acid	A sour astringent, slightly pungent aromatic associated with vinegar.	Aroma/Flavor 0.5% acetic acid solution= 2.0 (a), 2.0 (f) 1% acetic acid solution = 2.5 (a), 3.0 (f) 2% acetic acid solution = 3.0 (a) 4.5 (f)
Overall Impact	The maximum overall sensory impression during the whole tasting time.	Amplitude Gevalia Kaffe Traditional Roast ground medium coffee=7.5 Folgers Classic Roast Ground Coffee (brewed) = 9.0 Folgers Classic Roast Instant Coffee crystals=12.0(f)

Balance/Blended	The melding of individual sensory notes such that the products present a unified overall sensory experience as opposed to spikes or individual notes.	Amplitude Folgers Classic Roast Instant Coffee crystals=3.0 Folgers Classic Roast Ground Coffee (Brewed) = 6.0 Gevalia Kaffe Traditional Roast Ground medium coffee=10.0
Longevity	The time that the full integrated sensory experience sustain itself in the month and after swallowing.	Amplitude Gevalia Kaffe Traditional Roast Ground medium coffee=7.5 Folgers Classic Roast Ground Coffee (Brewed) = 9.0 Folgers Classic Roast Instant Coffee crystals=12.0(f)
Fullness	The foundation of flavor notes that gives substance to the product. The perception of robust flavor that is rounded with body.	Amplitude Folgers Classic Roast Instant Coffee crystals=5.0 Folgers Classic Roast Ground Coffee (Brewed) = 7.5 Gevalia Kaffe Traditional Roast Ground medium coffee=10.0
Fidelity	The total sensory experience of the trueness of the product in the stated context; its believability.	Folgers Classic Roast Instant Coffee Crystals Folgers Classic Roast Ground Coffee Gevalia Kaffe Traditional Roast Ground medium coffee
Mouth Drying	A drying puckering or tingling sensation on the surface and/or edge of the tongue and mouth.	Texture 0.05% Alum Solution = 2.5 0.07% Alum Solution = 3.5
Viscosity	The thick feel of the beverage as you press your tongue through it.	Texture 5% sucrose solution = 2.0 Campbell's Tomato Juice = 4.0
Oily	The amount of fat/oily film left on surfaces of mouth after swallowing or expectorating.	Texture Horizon Organic low-fat UHT milk = 3.0 Kroger Half n' Half = 6.0

* Intensities are based on a 15-point numerical scale with 0.5 increments, where 0 means "none" and 15 means "extremely strong".

Descriptive analysis to validate the coffee lexicon

Figure 2-1 shows the results of the validation with key terminology found in most coffee samples. Based on this test, the trained panel found differences among the coffee samples; these differences were visualized using Principal Components Analysis (PCA).

As seen on the map, samples A, C, and D were stretched in the area of the flavor attributes sweet and dried fruit. Sample E was characterized by having higher grain and sweet aromatics notes. Samples B, G, and F, were closed to the flavor attributes grain and nutty. These samples were more related to "pleasant" notes. According to Nebesny & Budryn (2006), sweetness has a beneficial impact on the overall taste of coffee which means that sweeter coffees will probably be better balance than less sweet ones. These researchers also explained that nutty notes are as important as the sweetness of the coffee. They explained that substances that confer nutty notes (mainly pyrazines) are most intensively produced during the initial stage of roasting. However, a continuation of roasting contributes to the degradation and generation of other compounds that will lower the intensity perception of the nutty flavor (Nebesny & Budryn, 2006).

This situation could explain the other side of the PCA map where samples T and S were stretched together in the area of sour, metallic, petroleum, bitter, astringent, burnt, acrid, ashy, smoky, and pungent. These notes could be characteristic of higher roasted coffees. Burnt aroma and bitter flavor attributes are characteristic of dark roasted coffees. Astringency and bitterness are generated by the thermal degradation of chlorogenic acids (CGA) during the roasting process (Nebesny & Budryn, 2006; Kreuml, Majchrzak, Ploederl & Koenig, 2013). According to literature, attributes like burnt, smoky, astringent, and bitter are negatively associated aroma and flavor attributes of coffee, whereas, sweet, nutty and fruity are positively associated (Nebesny & Budryn, 2006; Kreuml, Majchrzak, Ploederl & Koenig, 2013).

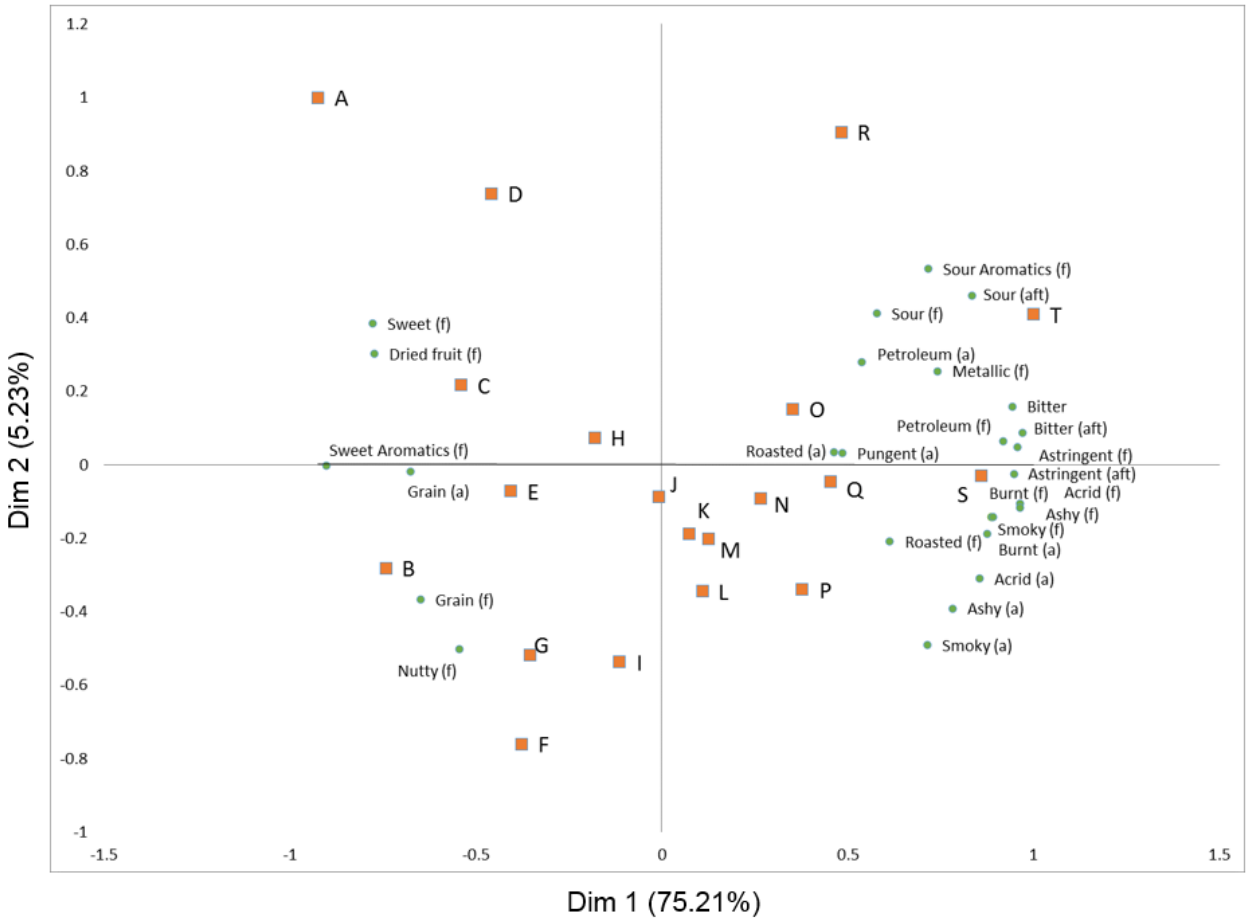

Figure 2-1 Principal Component Analysis (PCA) of the trained panel evaluations for aroma (a), flavor (f) and aftertaste (aft) attributes of Colombian coffee samples from Set 4.

As shown in Figure 2-1, the coffee lexicon allowed panelists to described specific characteristics that were present in the coffee samples. The developed attributes and references were successfully used to describe coffee samples diversity. By looking at the map of coffee samples it is possible to examine the location of these samples in the PCA. There are coffee samples in all the four quadrants of the map, which indicates that even if is a small set from the same region (20 samples from Colombia) the coffee lexicon allowed the panelists to have a variety of attributes that could explained small differences among those coffees.

Organization of the Lexicon

Based on further discussion from the trained panel and researchers some of the attributes were organized depending on their complexity level in different categories. Table 2-4 shows those categories that were rearranged depending on the attribute characteristics.

The attributes that are classified in the first level are shown in Table 2-3 without any letter or italic font, examples of those are acrid, smoky or olive oil. On the other hand, there are some attributes that are components of the first level attributes, those attributes represent a second level of complexity, for example, the attribute nutty is located on the first level of complexity, and it is later divided into three more specific attributes: hazelnuts, almonds, and peanuts. The second level is represented in Table 2-3 with a letter "a" as a superscript.

There is also a third level of complexity for some attributes, for example, the attribute fruity is part of the first level, then fruity is divided in: citrus fruit (second level), and citrus fruit at the same time is divided in lime, lemon, grapefruit, and orange (third level of complexity). This third level is represented in Table 2-3 with a letter "b" as a superscript and italic font.

Table 2-4 Different levels of complexity present in the Coffee Lexicon.

Attributes		
Level 1	**Level 2**	**Level 3**
Spices	Pungent	
	Spice Brown	Nutmeg Clove Cinnamon
	Black Pepper Anise	
Sweet Aromatics	Overall Sweet	
	Brown sweet	Caramelized
	Vanilla Vanillin	
Nutty	Hazelnut Almond Peanuts	
Chocolate	Dark Chocolate	

Floral	Rose Jasmine Chamomile	
Green	Under-ripe Peapod Herb-like Hay-like Vegetative Fresh Dark Green	
Fruity	Dried Fruit:	Prune Raisins
	Citrus Fruit:	Lemon Lime Grapefruit Orange
	Berry Fruit:	Blackberry Raspberry Blueberry Grape Cherry
	Stone Fruit:	Peach Pear Apple
	Other fruit:	Pineapple Coconut
Tobacco	Cigar Pipe Black tea	
Alcohol	Whiskey	
Musty	Dusty Earthy Moldy damp Phenolic	
Animal	Animalic Meaty/Brothy	
Chemical	Rubber Petroleum Medicinal Skunky	

The categories in the coffee lexicon help represent different characteristics that can be present in coffee samples from different varieties. These categories are hard to describe in charts, for this

reason, a “coffee tree” was created with the purpose to visualize the multiple levels of representation of the lexicon (Figure 2-2). This was a first approach to understanding the relationships between attributes, and also the complexity of the categories that help to describe the aromas and flavors present in coffee.

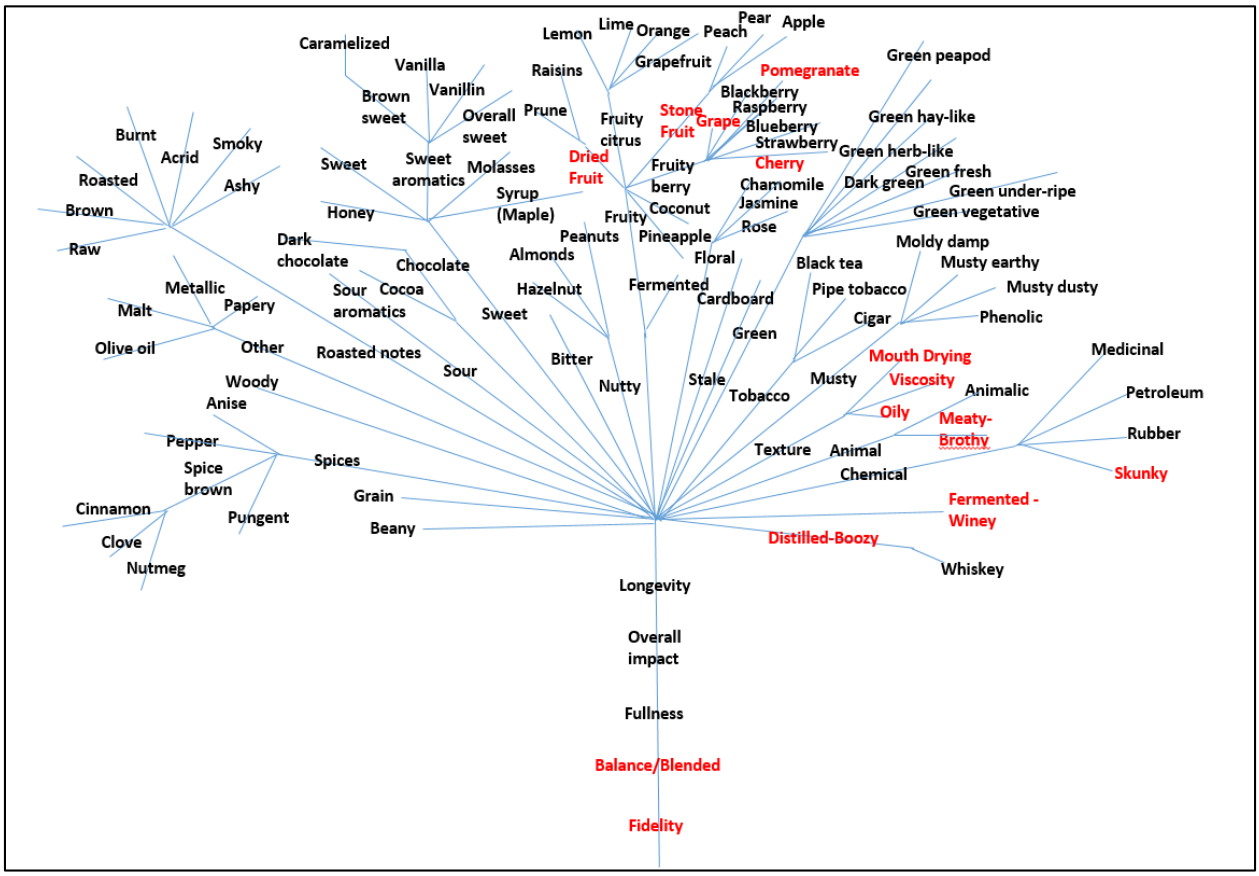

Figure 2-2 Graphic representation of the lexicon attributes.

CONCLUSION

A complete lexicon including attributes, references and intensities was developed for sensory evaluation of coffee. The lexicon was successfully used to evaluate coffee samples. Future studies should validate the utilization of this lexicon with different sensory panels, as well as samples from various parts of the world that contain unique features that allow the use of specific attributes such as blueberry or lime. This lexicon should be considered a living document that

can be added to or modified over time when needed. The final version of the lexicon includes 110 attributes, in future research it will be necessary to narrow this list down to have appropriate sub-lexicons for specific objectives such as evaluation of coffee varietals, processing evaluation, fermentation degree of roasting evaluation, a lexicon specific for the assessment of coffee defects, and even a coffee lexicon for specific kinds of coffee preparations; for example, a sub-lexicon for espresso or cappuccino. Another purpose of future studies is to find a way to visually show the multiple levels of organization that are represented in the coffee lexicon. To accomplish this goal it is necessary to establish the relationships among attributes, this will help to understand the complexity of the coffee aroma and flavor from the sensory point of view.

The lexicon developed in this study is relevant for sensory scientists but also for industry and coffee producers. Coffee descriptions can be made based on this terminology and can be used for consumer education and also in product development of beverages related to coffee.

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Chapter 3 - Determination of differences among brewing methods

ABSTRACT

Many products are sold that will be prepared by consumers in ways that suit their particular needs. For example, coffee may be prepared in a variety of different ways depending upon the occasion and the purpose, even when sensory testing is conducted. This study identified how the sensory properties of a preparation method used in a controlled sensory study or a quality grading system compared to those used with consumer preparation methods for three different high quality coffees. Colombian coffees prepared using a consumer drip coffee maker, a home or food service automated espresso machine, a coffee grader "cupping" method and a filtered infusion method were tested by trained panelists. The cupping method produced a higher intensity for the "roasted" flavor attribute across all samples. This method also tended to produce higher scores for burnt and acrid than other brewing methods. Flavor and aroma attributes both varied with preparation methods, but not necessarily in the same ways. Surprisingly, the drip brewing method showed the most differences in the three coffee samples for aroma, flavor and aftertaste attributes, but other methods may be appropriate depending on the objectives.

PRACTICAL APPLICATIONS

Results suggest that differences in the intensity of flavor and aftertaste attributes of coffee samples depend on the brewing method used to prepare them. Thus, using only one method when conducting sensory or quality testing can be a limiting component in the information gathered in a sensory study, in this case, coffee. The brewing method is a critical factor to consider in future coffee studies with the best method used depending on the objectives of each researcher and the ultimate goal of each study.

INTRODUCTION

Descriptive analysis studies are conducted to describe the specific sensory characteristics (e.g. flavor, texture, appearance) of products, often using trained panelists for evaluation. Consumer studies can also be carried out to identify or explore perceptions about quality. In both scenarios, however, sensory analysts usually are careful to detail specific preparation methods to ensure uniformity of samples for evaluation. For example, studies have been published that provide information on exactly how preparation should be done for certain studies to obtain particular types of data (Romero Del Castillo, 2012; Lee, 2008).

However, with many products, multiple preparation methods are possible. For example, soft drinks are consumed at different temperatures, with and without ice, poured into separate containers, and consumed directly out of packaging with various sized holes. Spence and coworkers (Michel et al., 2015; Wan et al., 2015; Piqueras-Fiszman and Spence, 2012) showed that changes in the container or placement of food in the container had an impact on consumer perception of the product.

Other researchers have shown differences in product preparation methods. Bach et al., (2013) found some differences in both the attributes present and their intensities when using two different cooking methods for Jeruselum artichokes. They suggested that the preparation methods resulted in “unsystematic product differences related to the methods of preparation rather than to product”. Cherdchu and Chambers (2014) showed that the carriers used for certain food products had an impact on the flavor of the product under study. Similarly, Hanson et al. (2012) showed that simple differences in preparation such as the final “flaming” after heating at the end of flambéed foods produced different sensory properties. Sveinsdóttir et al., (2010) reported that varying the preparation of fish as done in consumer home use tests reduced the ability to find differences among products as would be done in controlled situations such as

central location consumer studies or descriptive analysis with trained panels. Even non-food products can vary in their application and use parameters, which can affect sensory properties (e.g. Hightower and Chambers, 2009).

Coffee is one of the most popular aromatic beverages around the world, having desirable flavor characteristics that are appreciated by consumers everywhere. In recent years, there has been a high demand for good quality coffee from countries like Brazil, India and China, and these countries are now competing with the United States to purchase gourmet coffee beans (Specialty Coffee Association of America, 2012).

There are many species of coffee beans, however, only two have proved to be commercially viable: *Coffea Arabica and Coffea Canephora (Robusta).* Arabica is the original Ethiopian species, considered superior in taste and represents 75% of the world's consumption. On the other hand, Robusta has twice the amount of caffeine, is more disease resistant, better resists hot growing temperatures and has a more bitter taste (Smith, 2007).

Coffee beans are produced in more than 60 developing countries and this presents an important opportunity for farmers and small family producers, considering the income potential of coffee bean production. At least 14 countries depend on coffee for 10% or more of their export earnings and in the case of Burundi, Ethiopia, and Uganda, three of the least developed countries producing coffee, it represents more than 50% of their exports. However, only three countries (Brazil, Colombia, and Vietnam), account for almost 60% of the world's coffee bean production (Consumers International, 2005).

Since this beverage is so important to the economy of these countries, it is necessary to consider consumers' demands and how coffee is being used around the world. This beverage can be prepared in various ways by consumers and is prepared differently when it is "cupped" for

quality grading and when prepared for controlled sensory testing by trained panels. DiDonfrancesco et al. (2014) showed that sensory panels and cuppers provided different information on coffee and that both were useful to understand coffee.

The aim of this study was to determine how the preparation method of a widely used product could affect the sensory properties of three different coffees. Four methods of preparation: a consumer coffee maker, a home or food service automated espresso machine, a coffee grader "cupping" infusion (containing particulate matter), and a filtered infusion method (cupping method with filtration – similar to a French press procedure) were used for this study.

MATERIALS AND METHODS

Coffee Samples

For the present study, three high-quality Colombian coffees (Arabica, v. *Caturra*) were used; the coffees were chosen to represent slightly different characteristics in a preliminary review of 20 samples. The coffee samples selected were "El Porvenir," produced at an altitude of 1500 m.a.s.l (mean above sea level)., "Los Andes," produced at an elevation of 1800 m.a.s.l., and "Las Brisas," produced at an altitude of 1400 m.a.s.l.. Some of the main production characteristics of these three samples are summarized in Table 3-1. All samples were processed and roasted to a medium roast by Mild Coffee Company (Huila, Colombia) from samples obtained from their farm contacts. The three coffee samples were selected from the set 4 (20 Colombian coffee samples) of the coffee lexicon development project.

Table 3-1 Description of the three Colombian coffee samples used for the present study.

Sample	*Altitude*	*Fermentation Time*	*Drying Time*	*Shade Type*
El Porvenir	1500	1 week	2 to 8 days	Without shade
Las Brisas	1400	12 hours	1 week	Without shade
Los Andes	1800	12 hours	5 to 10 days	Without shade

Brewing preparation

The amount of coffee sample evaluated was determined according to the ISO 6668:2008 reference that recommends a ratio of 7.0g of coffee per 100 ml of water, with an individual notified coffee range of 5g to 9g (International Standard ISO 6668:2008). Although various brewing methods may sometimes recommend different amounts of coffee, the amounts were standardized in this test in order to ensure that the coffees, not the amount, were compared.

Each of the coffee samples was prepared by grinding the roasted beans in a Hamilton Beach coffee bean grinder Model 80335 (Hamilton Beach Brands, Inc., Glen Allen, Virginia, USA) for 15 seconds. The grinding time is an important step in the process because it creates more surface area from which the hot water can extract components that contribute to the aroma and flavor of coffee (Brown, 1999). Although various coffee brewing methods recommend different grind degrees (i.e. grind size), the level of grind in this study was the same to focus solely on the brewing method.

The samples were ground no more than 30 minutes before the evaluation to preserve the volatile compounds and freshness of the coffee samples. For this study we used deionized, carbon-filtered water with the aim of keeping the water neutral in pH and odor-free, without any component that could add a new aroma or flavor attribute different from the ones produced by the coffee. The International Standard ISO 3972 recommends that water should be neutral, tasteless, still and odorless, and preferably of known hardness (International Organization and for Standardization, 1991).

Deionized water has been used in previous studies with the purpose of minimizing the potential for unwanted flavors from the brewing water (Lawless, et al., 2005; Hoehl et al., 2010). However, other authors suggest that tap water is better because deionized water produces a more sour taste in cups of coffee (Brown, 1999).

Four different brewing methods were used to prepare the samples:

a. Consumer drip coffee maker: 1.5 liters of water at room temperature, was added to a General Electric Coffee Maker Machine (Model 169058, Capacity 12 cups. General Electric (GE), NY, USA). 87.5g of ground coffee were put into the coffee filters and then into the coffee maker machine. For this study, we used Melitta Cone Coffee Filters, Natural Brown, No. 4 (Melitta USA, Inc., Clearwater, FL, USA).

b. Home or foodservice automated espresso machine: for the preparation of the samples we used an Espresso Machine, brand Jura, model IMPRESSA C5 (JURA Inc., Montvale, NJ, USA) filled with the water used throughout this study. Although this machine will grind samples automatically, we put preground coffee into the espresso machine. Each sample was prepared individually, and the machine took around 10 to 15 seconds to prepare the sample.

c. Coffee grader "cupping" infusion: Water was heated to 200F (93C) and then was poured into an air pot container to keep it warm. Then 7g of the ground coffee was placed in 4oz Styrofoam cups. Immediately before serving 100 ml of hot water was poured over the grounds. After three minutes, each panelist broke the crust that was formed to evaluate aroma. Finally, after 8 minutes of infusion, grounds were pushed to the bottom of the cup by spoon and each panelist proceeded to assess the flavor of the coffee by aspirating/slurping the coffee with a large metal spoon to cover as much area as possible in the mouth and aerate the coffee.

d. Filtered infusion method: Water was heated to boiling point (around 100C). Meanwhile, 87.5g of roasted beans from each sample were ground for 15 seconds. After the water reached the boiling point an amount of 1.5 liters was poured into a cup containing the ground coffee. The infusion was then covered with a lid for 3 minutes and then stirred; the resulting infusion was

filtered through a metallic sieve and transferred into the respective coded thermos to maintain the correct serving temperature (70C).

Specific information on the key differences of the brewing preparation methods can be found in Table 3-2.

Table 3-2 Key Differences of the Brewing Preparation Methods

Preparation Method	Water Temperature	Filters Used	Materials of the machine
Consumer drip coffee maker	~94-95ºC	Paper	Plastic
Home or foodservice automated espresso machine	92 - 94ºC	Stainless Steel	Stainless Steel
Coffee grader "cupping" infusion	93 ºC	No	Stainless Steel
Filtered infusion method	100 ºC	Stainless Steel	Stainless Steel

Water temperature

In this study, the water temperature used for the four methods was carefully controlled to the extent possible because varying brewing temperature could result in differences in the intensity of flavor and aftertaste attributes. For the espresso machine method the water temperature was in a range between 92 - 94ºC. This temperature was similar to the one used to prepare the coffee with the cupping method where we used water at a temperature of 93ºC. Similarly, the home-style drip coffee maker also heat the water to just below the below boiling point (~94-95ºC). However, for the infusion method, we used boiling water to prepare the coffee samples according to the International Standard ISO 6668:2008 that recommends to heat the water to the boiling point during the preparation of the beverage.

The differences in the water temperatures are inherent in the extraction methods. If the water is colder, some of the soluble compounds present in the coffee will not be extracted, resulting in more sour and acidic flavors. On the other hand, if the water is too hot, some undesirable

elements will be extracted which affect the taste, especially in terms of bitterness (Food Management, 2011).

Panelists and Sensory Procedure

For this study, six highly trained panelists (two males and four females; age range 50-70 years) from the Sensory Analysis Center at Kansas State University, evaluated the coffee samples. The panelists' experience included 120 hours of general training and a minimum of 1200 hours of general sensory testing of beverages and food products including coffee. Two days of orientation were conducted (2-hour sessions each day), with the primary objective of familiarizing the panelists with the references, the coffee samples, and the evaluation process. After these orientation sessions six sessions of 2 hours were held for the samples evaluation. A total of 2 samples were evaluated per session.

Similar panels have been used by others for sensory tests (e.g. Ledeker et al., 2014; Rosales and Suwonsichon, 2015). Samples were labeled with three-digit codes and were presented to the panelists in 4oz Styrofoam cups for their assessment. Samples were evaluated by the panelists individually one sample at a time and then the consensus method as used in other recent studies (Vázquez-Araújo, 2014; Suwonsichon et al., 2012; Di Donfrancesco, Koppel, & Chambers, 2012) was used to determine a final score for the intensity of the attributes that were present in each sample. For each of the coffee samples the panel leader led a discussion one sample at the time to determine the consensus scores for each of the attributes that were evaluated in this study.

The panelists evaluated aroma, flavor, and aftertaste for every sample. The attributes for aroma were: roasted, burnt, acrid, ashy, brown, smoky, woody, cocoa, chocolate and coffee ID; for flavor: roasted, burnt, acrid, ashy, smoky, woody, astringent, bitter, sour, brown, cocoa, coffee

ID and chocolate; and for aftertaste: bitter, sour, astringent. The attributes of each sample were identified and the intensity was quantified utilizing a 0-15 point scale with 0.5 increments (0.0 = none; 0.5-5.0 = slight; 5.5-10.0 = moderate; 10.5-15.0 = extreme). The list of references used in this study is shown in Table 3. To cleanse their mouth between every sample, the panelists used bagels and apples, and they also breathed through a warm, clean, cotton terry cloth filter to clean their nasal passages.

Table 3-3 References used for the evaluation of coffee samples.

Attribute	Definition	Reference
Roasted	Dark brown impression characteristic of products cooked to a high temperature by dry heat. Does not include bitter or burnt notes.	- Planters Dry Roasted Unsalted Peanuts = 5.0 (a), 5.0 (f) - Jean Lenoir, Le Nez du Café "No. 6" roasted coffee= 7.5 (a)
Burnt	Dark brown impression of an over-cooked or over-roasted product that can be sharp, bitter and sour.	- Alf's Red Wheat Puffs (2 pieces in the mouth) = 8.0 (a), 3.0 (f)
Acrid	The sharp, pungent, bitter or acidic aromatics associated with products that are excessively roasted or browned.	- Alf's Red Wheat Puffs (2 pieces in the mouth) = 8.0 (a), 3.0 (f)
Ashy	Dry, dusty, dirty or smoky aromatics associated with the residual of burnt products.	-Gerkens Midnight Black (BL80) cocoa Powder = 2.5 (a), 3.5(f) - Benzyl disulfide = 4.0 (a)
Brown	A rich, full, round, aromatic impression always characterized as some degree of darkness generally associated with attributes such as toasted, nutty, roasted, or sweet.	- C&H Golden brown sugar = 3.0 (a), 7.0 (f) - Bush Pinto Beans (canned) = 6.0 (a), 3.0 (f)
Smoky	An acute, pungent aromatic that is a product of combustion of wood, leaves or non-natural product.	- Benzyl disulfide = 3.5 (a) - Diamond Smoked Almonds = 6.0 (a), 5.0 (f)
Woody	The sweet, brown, musty, dark aromatics associated with the bark of a tree.	- Diamond Shelled Walnuts = 4.0 (f), 4.0 (a)
Cocoa	A brown, sweet, dusty, musty, often bitter aromatic associated with cocoa bean, powdered cocoa, and chocolate bars.	- Hershey's Cocoa Powder in water = 7.5 (a), 5.0 (f)

Chocolate	A blend of cocoa including cocoa butter and dark roast aromatics at varying intensities.	- Nestle` Semi-sweet chocolate chips (taste 1 chip) = 7.5 (f), 8.0 (a)
Coffee ID	A distinctly roasted brown, slightly bitter aromatic characteristic of brewed coffee. Additional descriptors may/may not include: woody, oily, acidic, and full bodied, and these notes may occur at varying intensities.	-Folgers Classic Roast instant coffee crystals = 3.5 (a), 4.0 (f) -Folgers Classic Roast ground coffee = 6.0 (a), 7.0 (f) -Gevalia Kaffe Traditional Roast ground medium coffee = 8.5 (a), 8.0 (f)
Astringent	A drying, puckering or tingling sensation, on the surface and/or edge of the tongue and mouth.	0.03% Alum Solution = 1.5 0.05% Alum Solution = 2.5 0.07% Alum Solution = 3.5 0.10% Alum Solution = 5.0
Bitter	The fundamental taste factor associated with a caffeine solution.	0.01% Caffeine Solution = 2.0 0.02% Caffeine Solution = 3.5 0.035% Caffeine Solution = 5.0 0.05% Caffeine solution = 6.5 0.07% Caffeine solution = 10
Sour	The fundamental taste factor associated with a citric acid solution.	0.015% Citric Acid Solution = 1.5 0.05% Citric Acid Solution = 2.5
Overall Impact	The maximum overall sensory impression during the whole tasting time.	- Gevalia Kaffe Traditional Roast Ground medium coffee=7.5 (f) - Folgers Classic Roast Ground Coffee (Brewed) = 9.0 - Folgers Classic Roast Instant Coffee crystals=12.0 (f)
Body/Fullness	The foundation of flavor notes that give substance to the product. The perception of robust flavor that is rounded with body.	- Folgers Classic Roast Instant Coffee crystals=5.0 (f) - Folgers Classic Roast Ground Coffee (Brewed) = 7.5 - Gevalia Kaffe Traditional Roast Ground medium coffee=10.0 (f)

Data Analysis

This study was a 3 x 4 factorial experiment. The consensus scores were used in a two- way Analysis of Variance (ANOVA) with brewing method and coffee samples as the sources of variation. The statistical program SAS v.9.2 was used to conduct this analysis of variance, for the source of variation “sample” with two degrees of freedom and another analysis of variance for the source of variation of method with three degrees of freedom. The consensus scores used in

this analysis are based on multiple samples of each coffee, but they are not averages, they are single scores for each attribute agreed upon by all panel members. Thus, individual coffee samples with different values are, by default, different. This ANOVA in this study did not compare individual coffees, but rather compared coffees across types and brewing methods. Keane (1992) suggested that interpretation of consensus profile terms and intensities provide a detailed blueprint of a product. The strength of the method rests on the ability of the group of highly trained panelists to work as a team to reach this consensus, which depends on the appropriate selection of panelists and extensive training on the product. All these elements were meet by the trained panel involved in this study.

RESULTS AND DISCUSSION

Overall differences among coffees and brewing methods

As expected, different coffees and different brewing methods were significantly different ($P<0.05$) for most attributes. For example, El Porvenir has higher overall coffee ID than Las Brisas and Los Andes (all brewing methods averaged) and the espresso method produces higher coffee ID overall than the other brewing methods (averaged across coffees). However, those overall differences fail to account for the differences in coffee sensory properties when we examine the interaction of coffee and brewing method. That information must be gained by individually examining the consensus scores for each coffee and each brewing method individually.

Differences among coffees using different brewing methods

Figure 3-1 shows the aroma sensory profiles of the three coffee samples that were used in the present study. According to this figure, there were differences in the sensory properties of each coffee sample due to the brewing method. Las Brisas was one of the samples that presented a

greater variability obtaining higher scores for the attribute “roasted” when it was prepared with the espresso machine but at the same time this attribute scored lower when it was prepared with the drip coffee maker. Other attributes also showed variability depending on the brewing method for this sample: coffee ID (higher with espresso machine and lower with the coffee maker machine) and chocolate (higher with the infusion method and inferior with the coffee maker and the cupping method).

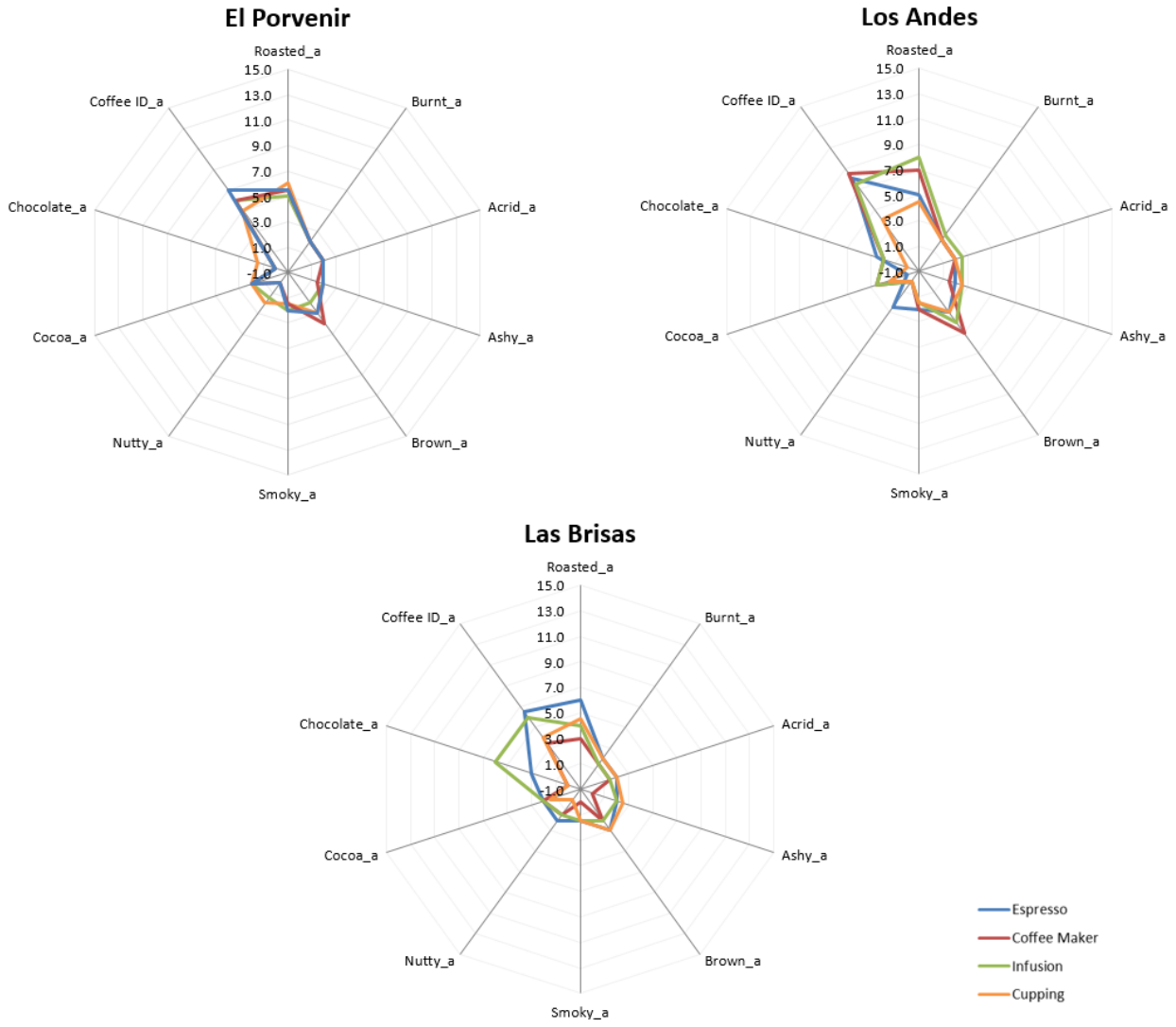

Figure 3-1. Aroma sensory profiles of the coffee samples.

In the case of the coffee sample Los Andes coffee there were differences in the intensities of the attributes depending on the brewing method as well. According to figure 3-1, the aroma attributes roasted (higher with infusion method and lower with the cupping method) and coffee ID (lower with the cupping method) also were affected by the brewing method.

El Porvenir presented the lowest variability based on the brewing method for the aroma attributes. For this sample the attributes burnt, acrid and cocoa scored similarly when they were brewed with the four methods.

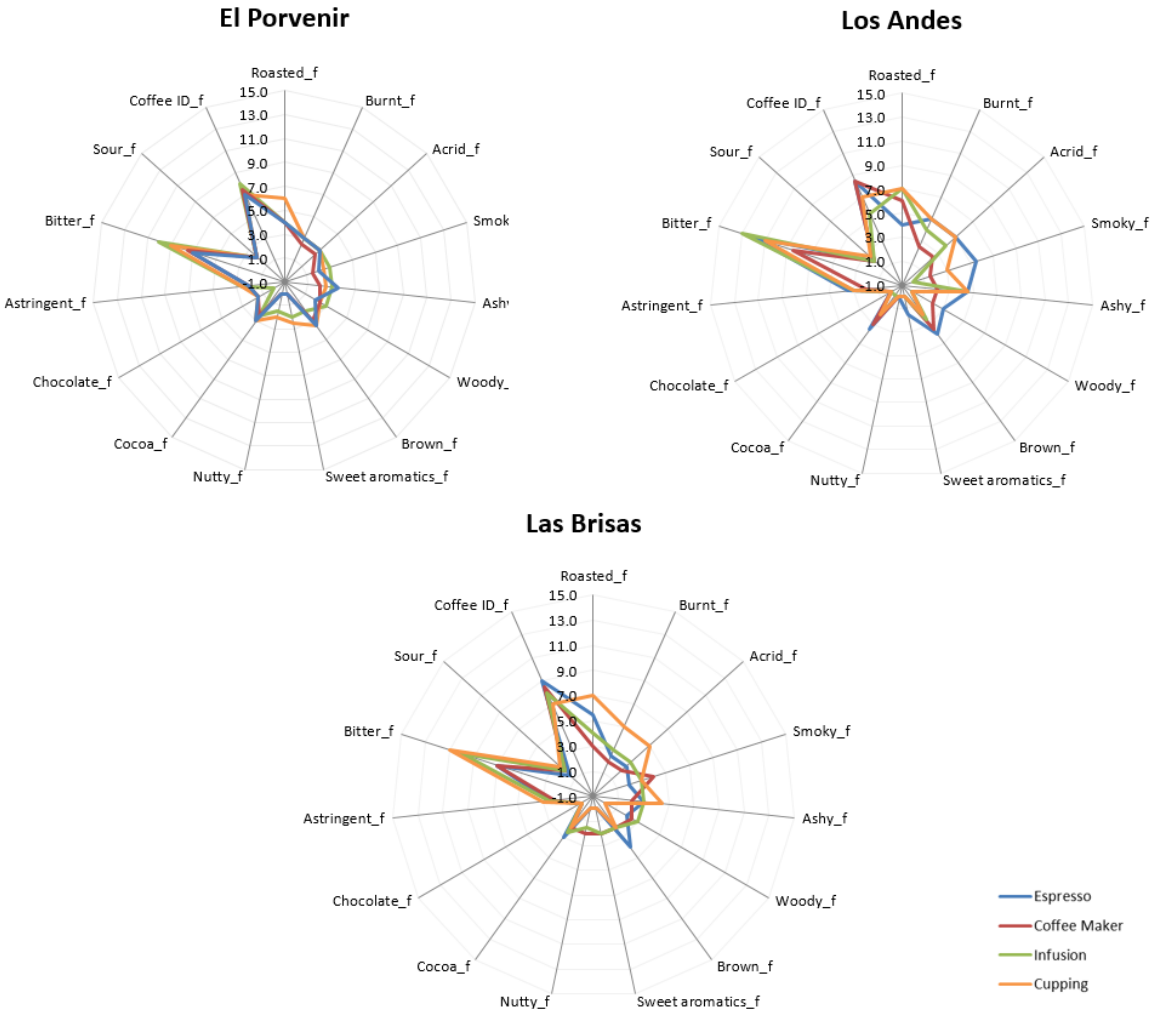

Figure 3-2. Flavor sensory profiles of the coffee samples.

Figure 3-2 shows the sensory flavor profile of the three coffee samples; there were also differences in this profile depending on the coffee brewing method that was used. Again, Las Brisas and Los Andes appear to show the greatest differentiation among the brewing methods although all the samples presented some differences in intensities. However, those differences in brewing methods were not necessarily in the same direction depending on the coffee. In general the cupping method tends to produce more intense notes for the attributes roasted, burnt and acrid. There also were differences in the intensity of the attributes: burnt, acrid, ashy, bitter, brown, coffee ID and cocoa across the four methods of preparation. The attributes sour and astringent were the two attributes that showed the least variability between the brewed coffee samples.

For most of the attributes the cupping method tend to produce higher notes than the coffee maker method, which probably can be explained because the coffee maker method uses a paper filter, while in the case of the cupping method the extraction takes place without any filter. According to the Specialty Coffee Association of America any method that uses a paper filter take away some oils and essences that get trapped in the filter during the extraction (Specialty Coffee Association of America, 2012).

These results are also in accordance with the results presented by Gloess, et al (2013). For this study they used the consensus method to determine the sensory attributes of a group of coffee samples and they found that the body and texture was higher when the coffee samples were prepare with a espresso machine (automatic and semi-automatic) and the same attribute was lower when the coffee sample was prepare with a coffee maker machine using a paper filter and the Karlsbad method.

Figure 3-3 shows the aftertaste sensory scores of the three coffee samples. The cupping method tends to have more intense notes than the other methods for the attribute bitter. In general, there were differences in all the attributes of the aftertaste sensory profile, although sour aftertaste seemed to vary only slightly among the four brewing methods for all the coffees.

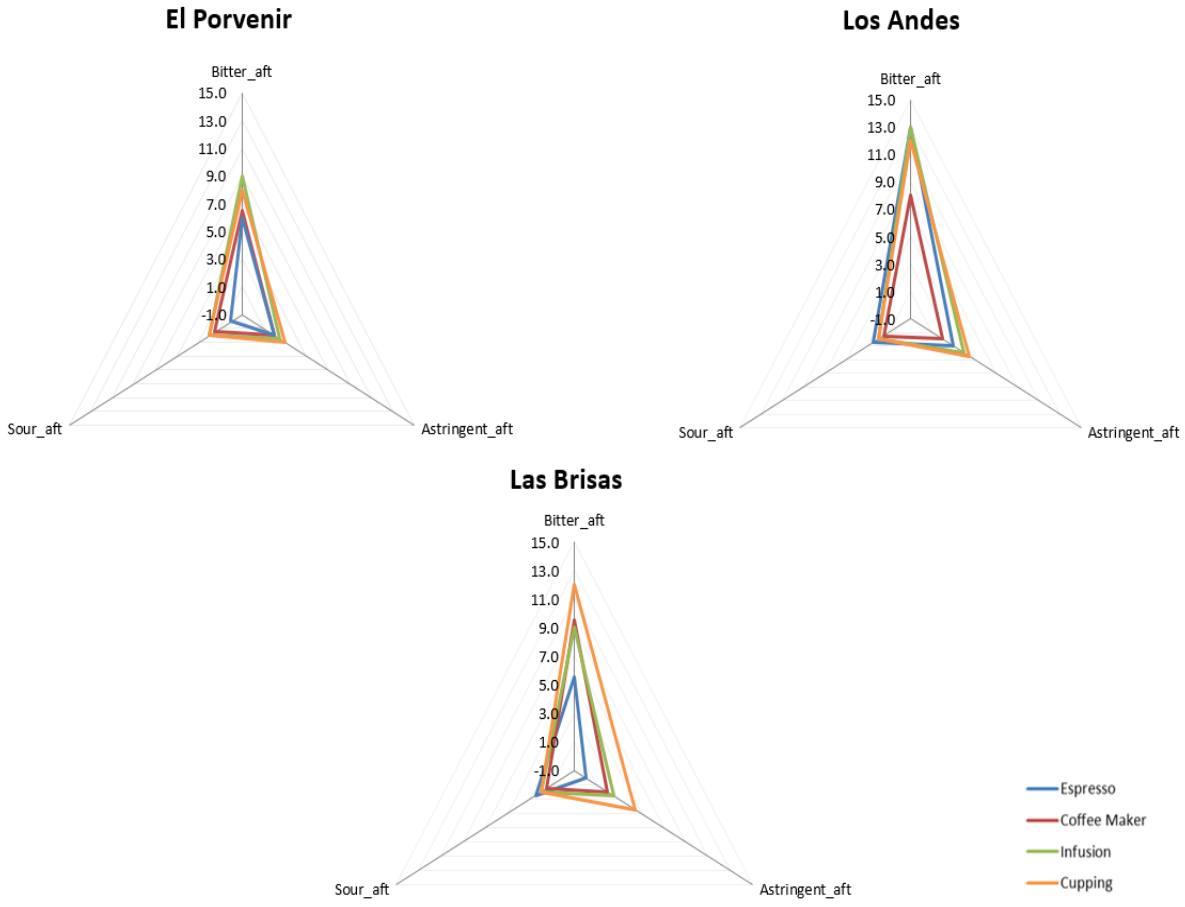

Figure 3-3. Aftertaste sensory profiles of the coffee samples.

In general, the attribute roasted presented some of the largest differnces across the four methods. This is important because roasted character is one of the most critical characterisitcs in coffee. According to DeRovira (2006), during the roasting process the coffee beans are exposed to high temperatures and the bean's sugars undergo what is known as caramelization. At this point, the flavors formed by this process fall into the category of "brown characters." As the temperature

rises, the Maillard Reaction occurs, which handles flavors that are usually described in the flavor lexicon with words like “roasted” and “chocolate.” Thus, flavors such as roasted and chocolate play a distinctive role in the final flavor of coffee and clearly are affected by the extraction methods chosen for brewing.

In this sutdy, each coffee sample sensory profile varied depending on the brewing method that was used. Such differences become important to the manufactuerer as this plays a key issue in selection of cultivars and processing methods for certain brewing conditions. It also is potentially important to consumers as they select coffee for particular brewing systems they have in their homes. For sensory analysts this variability creates another level of concern when selecting control procedures for preparation of coffee, and potentially other products, in sensory tests.

Differences among coffees using the same brewing method

Another way of looking at the data is to determine if differences exist among the coffees for each brewing method (Fig 3-4, 3-5, 3-6). Figure 3-4 shows aroma differences in the three different coffees depending for each individual brewing method. The cupping method tended to show the fewest differences with the coffee maker and infusion method showing the largest. The coffee samples make in the automatic espresso machine fell somewhere in between the other methods. The coffee maker method identified different intensities for the aroma attributes roated, nutty, chocolate and coffee ID. The coffee sample Los Andes generally presented the highest intensities of those attributes, but there clearly were differences among the three samples.

For the infusion method differences among the three coffee samples were also shown, specifically in four aroma attributes: roasted, brown, chocolate and coffee ID. The espresso

method shoed differences in roasted and nutty, which the cupping method showed only one small difference in nutty aroma.

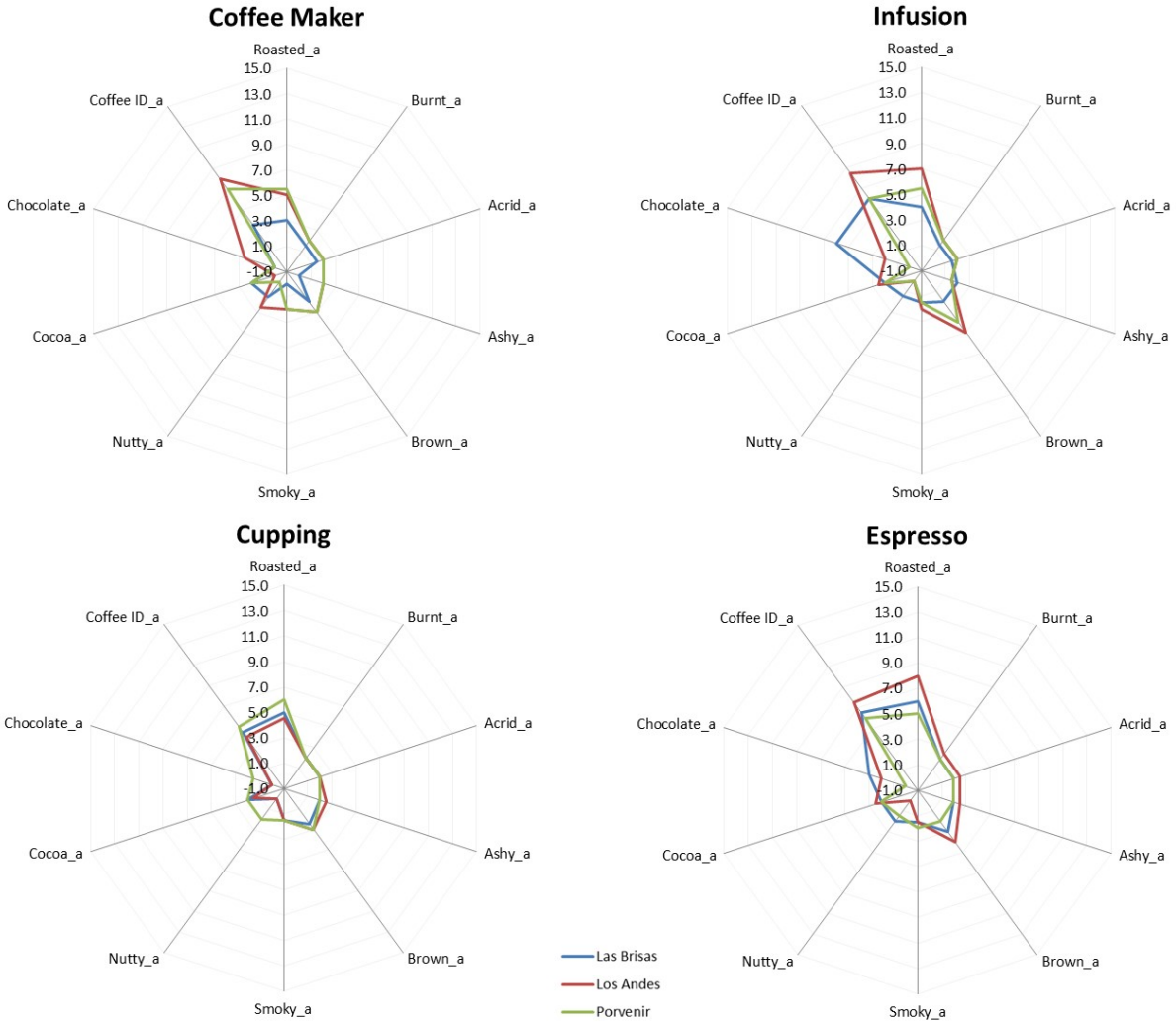

Figure 3-4. Aroma sensory profiles of the coffee samples based on the brewing method.

Figure 3-5 shows flavor differences in the three different coffees for each brewing method. For flavor attributes, the coffee maker, cupping method, espresso method tended to differentiate the samples more. The infusion method was not effective at showing differences in the characteristics of the coffee samples.

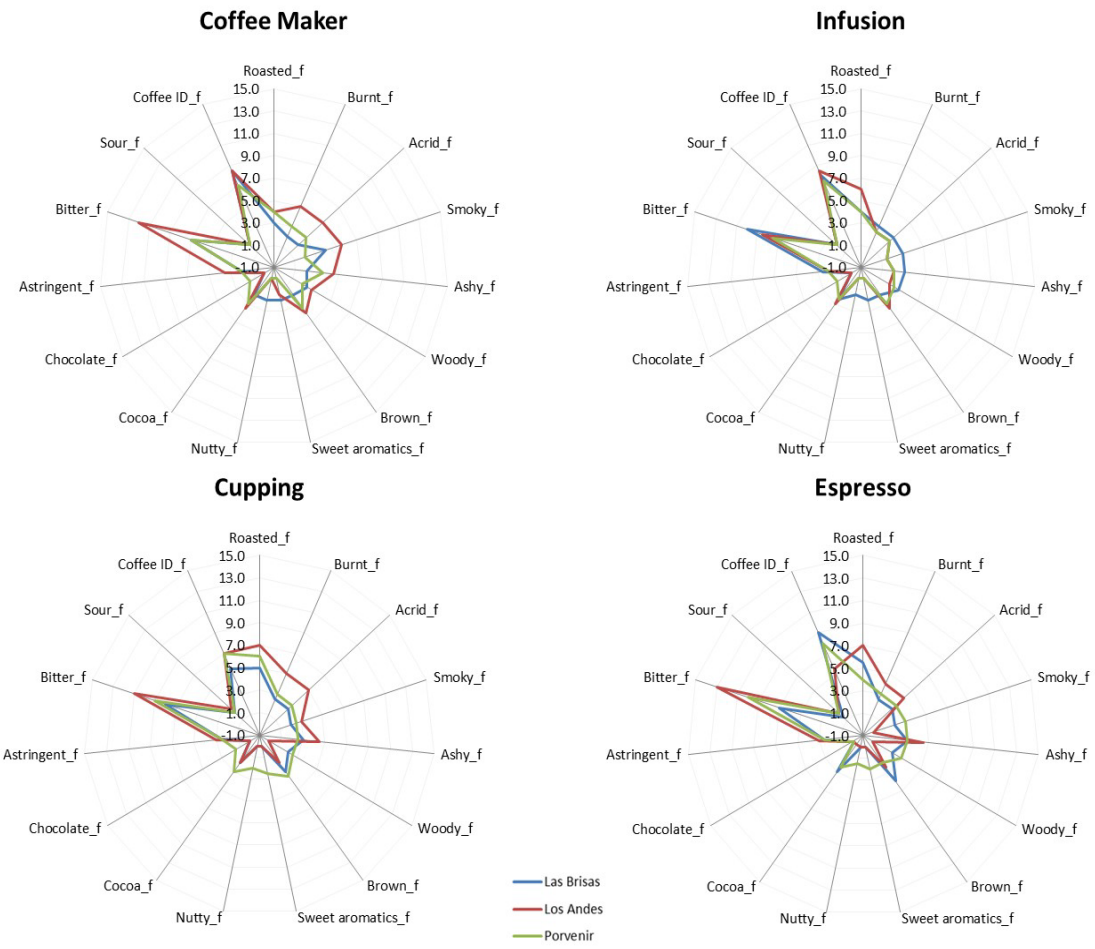

Figure 3-5. Flavor sensory profiles of the coffee samples based on the brewing method.

The cupping and coffee maker methods showed differences among the three coffees for burnt, acrid, smoky, woody, ashy, sweet aromatics and bitter flavors. The espresso method resulted in differences in roasted, smoky, woody, cocoa, bitter and coffee ID. This data would suggest that the espresso method was able to differentiate among the coffees for the overall coffee ID and roasted, but was less able to differentiate among some key negative attributes such as burnt and acrid. These results are consistent with a study made by Gloess et al. (2013), where they found that Espresso made from a semi-automatic machine and a fully automatic machine had a highest overall aroma intensity, and highest roasty notes.

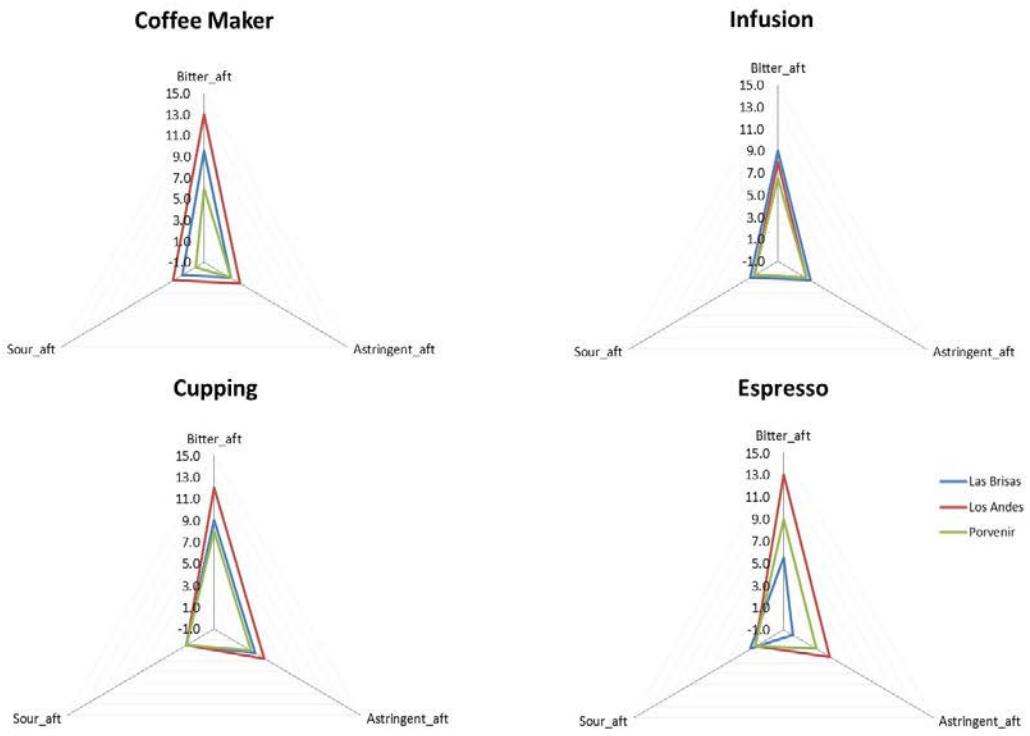

Figure 3-6. Aftertaste sensory profiles of the coffee samples based on the brewing method.

For aftertaste, the coffee maker and espresso methods showed the greatest differences among the coffees (Fig 3-6). The infusion method and the cupping method were not effective to show differences in the characteristics of the samples. The coffee maker method showed differences in all the aftertaste attributes, where the sample Los Andes presented the highest intensities for all three attributes.

The espresso method showed differences in the attributes bitter and astringent with the sample Los Andes also appearing stronger for those two attributes. Previous studies revealed that different brewing techniques, especially the pressurized ones will affect the concentrations of the caffeoylquinic acids (CQAs) in coffee extractions. These acids are responsible for the astringency and bitterness flavor and aftertaste present in coffee. The authors found that

pressurized methods could increase the concentration of this acids in coffee extractions (Blumberg, Frank, & Hofmann, 2010 & Moeenfard, Rocha, & Alves, 2014).

Differences in the intensity of each of the attributes in the coffee samples could also be explained due to the different components that were present in the various coffee samples. These components were extracted using the four brewing techniques, each of which allowed various levels of volatile and non-volatile compounds to dissolve into the hot water resulting in different intensities in the aroma, flavor and aftertaste attributes of the samples.

Illy (2002), a coffee manufacturer, suggested that when coffee is prepared using a filter drip coffee method like the standard consumer coffee maker, the soluble compounds present in roasted coffee, such as the acids and caffeine pass into the coffee solution. In contrast, the short contact time of water and coffee grounds in an espresso machine allows less acid and caffeine to dissolve into the brew.

In the espresso method, volatile compounds are captured by a pressurized water stream, this method uses high pressure to increase the efficiency of extraction resulting in more intense flavors (Thurson & Morris, 2013). This fact could explain why the espresso method was a good brewing mechanism to determine differences in flavor and aftertaste due to the efficacy of the extraction and the concentration of the components in the brewed coffee. All these differences will result in different aromas and flavors in the final brewed coffee.

For the infusion method boiling water was used to prepare the coffee samples. Water at or above the boiling point increases the solubility of volatile compounds present in coffee. The volatile compounds responsible for flavor can escape the brewing coffee above boiling temperatures, which is the reason why the aroma of coffee made with boiling water may be stronger, but would probably result in lower intensities of flavor attributes (Brown, 1999). This fact could explain

why the infusion method was effective to show differences in the aroma attributes but was not effective to show differences among the flavor and aftertaste attributes.

In general, the brewing method showing the most differences in the three coffee samples for aroma, flavor and aftertaste attributes was the drip coffee maker method. For this reason, the method could be viewed as the most appropriate method for use in sensory testing of coffee. However, the espresso method also was especially useful for flavor and aftertaste. The cupping method was suitable only for flavor, which is interesting since it is used for evaluating coffee "quality" that is based mostly on flavor characteristics. The infusion method only seemed to work well for differentiating aroma attributes. It is important to note that simply suggesting that the drip method should be used for future studies would be a superficial interpretation of this data. Although of the four methods tested, it differentiated among similar coffees best, it make not be appropriate for testing of coffee intended for situations where other methods would take precedence. For example, in some countries (e.g. Turkey) coffee is made using a method similar to the cupping procedure with large amounts of grounds. In other countries or situations where espresso is the primary drink consumed, manufacturers would be underserved if a drip system were used for testing. Similarly, the current use of pods or capsules may be change the testing system. Thus, the objective must lead the actual preparation system that should be used.

CONCLUSION

As expected, these results show that differences in flavor and aftertaste of a product, in this study coffee, depends, in part, on the preparation (brewing) method used to prepare the samples. These results have implications for sensory scientists and also for coffee producers who must select methods for testing that take into account multiple consumer preparation methods. Methods such as "cupping," which can work well for quick quality evaluations (Di Donfrancesco et al., 2014)

can produce descriptive results that do not match consumer experiences from consumer brewing methods such as drip coffee makers. Similarly, using brewing methods appropriate for standard consumer coffee may be inappropriate for evaluating coffee intended for other applications such as espresso.

During the preparation of product samples, it is important to follow all the procedures to be consistent with the methodology selected and also to ensure obtaining truthful and reliable results. The process of preparation of many products, such as coffee, is complex. For example, water temperature, holding time, holding temperature, and other aspects can cause the loss of many of the components that are characteristic of the product, and sensory properties flavor will change dramatically. Similarly, serving temperature and containers, which were controlled in this study, must be maintained to compare appropriately samples and characteristics of different products.

As a final observation, the preparation method is a critical factor to consider in sensory research, and the best option will vary depending on the objectives of each researcher and the ultimate goal of each study. Coffee is a complex beverage due to its chemical components and also due to the many steps that must be performed before the coffee cup can reach consumers. Further studies related to preparation methods for products such as coffee are necessary to demonstrate how these methods change with different samples.

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Appendix A - List of Coffee Samples used for the Lexicon Development

Set 1:

	Sample	**Weight(g);** Including bag's weight	**Weight(g);** Including bag's weight (Before Consumer Test)
1	ZONA SUR 319	1960	1640
2	ZONA SUR 325	2013	1850
3	ZONA SUR 331	2009	1717
4	ZONA SUR 335	2013	1838
5	ZONA MEDIA 320	1985	1783
6	ZONA MEDIA 321	2011	1831
7	ZONA MEDIA 322	2014	1799
8	ZONA MEDIA 327	2015	1846
9	ZONA MEDIA 334	2008	1794
10	ZONA NORTE 326	2017	1808
11	ZONA NORTE 328	2012	1840
12	ZONA NORTE 329	2020	1843
13	ZONA NORTE 332	2067	1889

Set 2:

Brand	Package Size	Details	Purchase Point
Archer Farms House coffee	12 oz	House blend, medium roast coffee, ground coffee	Target
Archer Farms Italian Coffee	12 oz	Italian roast, bold roast coffee, ground coffee	Target
Chock Full O Nuts (decaf)	4 oz (114g) 12 cups	Midtown Decaf, medium roast	Walmart
Chock Full O Nuts (original)	48 oz	Original ground coffee	Amazon
Coffee Bean & Tea Leaf Colombia Narino	12 oz (ground), 1lb (whole bean)		Amazon
Dunkin Donuts Dark	11 oz	Dark roast, original blend	Walmart
Dunkin Donuts Decaf	12 oz	Ground coffee	Walmart
Dunkin Donuts Original	24 oz	Medium roast, original blend	Walmart
Eight O Clock Original	36 oz	Whole bean	Walmart
Folgers Black Silk (ground)	27.8 oz	Ground coffee	Amazon
Folgers Gourmet Supreme dark coffee	27.8 oz	Ground coffee	Walmart
Folgers Instant Decaf	8 oz	Instant coffee crystals	Walmart
Gevalia Indian Malabar	8 oz	Dark roast, half the caffeine	Gevalia.com
Gevalia Kenyan	8 oz	Medium roast	Gevalia.com
Gevalia Mocca Java Coffee	8 oz	Ground coffee	Gevalia.com
Gevalia Papua New Guinea Coffee	8 oz	Ground coffee	Gevalia.com
Green Mountain Breakfast Blend Coffee	2.2oz packets	Ground coffee	Amazon
Green Mountain Dark Magic Coffee	12 oz	Whole bean	Amazon
Green Mountain Kenyan Highland	10 oz	Ground coffee	Amazon
Green Mountain Organic Mexican select	10 oz	Whole bean	Amazon
Illy Dark Roast	8.8 oz	Whole bean	Amazon

Intelligencia Coffee House Blend	12 oz	Drip grind coffee	Amazon
Millstone Kona Coffee Blend Ground coffee	12 oz	2 pack, ground coffee	Amazon
Maxwell House Ground	30.6 oz	Medium Roast, Ground coffee	Amazon
Maxwell House house blend	10.5 oz	Ground coffee	Walmart
Maxwell House Instant	8 oz	Intant coffee	Walmart
Maxwell House Master Blend	11.5 oz		Walmart
Maxwell House Original Ground	42.5 oz	Ground coffee	Amazon
Maxwell House Wake up coffee	30.65 oz	Mild, Ground coffee	Amazon
Melitta Extra Dark European Roast	10.5 oz	4 pack, ground coffee	Amazon
Mocca Java Coffee	8 oz	Gevalia, Ground coffee	Amazon
Nescafe Classico Instant Coffee	10.5 oz	Pure instant coffee	Walmart
Newman's own Newman's Blend Coffee	10 oz	3 pack, medium roast, ground coffee	Amazon
Peets House Blend	12 oz	2 pack, ground coffee	Amazon
Seattle's Best Coffee - level 4	12 oz	Ground coffee	Walmart
Seattle's Best Decaf level 3	12 oz	Ground coffee	Walmart
Starbucks Blonde Willow	12 oz	Ground coffee	Walmart
Starbucks Blonde Veranda Blend	20 oz		Walmart
Starbucks Decaf Espresso	16 oz	Whole bean	Amazon
Starbucks Espresso Ground Coffee	12 oz	Ground coffee	Walmart
Starbucks French Roast	20 oz	Ground coffee	Walmart
Starbucks Organic Yukon Blend Coffee	1 lb		Ebay
Starbucks Sumatra	12 oz	Ground coffee	Walmart
Starbucks Kenyan	1 lb	Whole bean	Amazon
Tully House Blend	64 oz	Ground or whole coffee	Amazon

Set 3:

Sample	Variety cultivated	Degree of roasting	Producer
Brazil Mogiana	Burbon, Mondo Nuovo Hybrid	456F	Cocapec
Guatemala Antigua	Caturra and Bourbon	465 F	Finca Bella Carmone
Mexican Chipas		437 F	Custepec
Organic "Kurimi" Ethiopia	Various inigenous varieties	75 Agtron Gourmet - light	Homecho Waeno Cooperative/ Sidama Coffee
Ngaita Kenya Limited Release	SL-28, Sl-34	75 Agtron Gourmet - light	Ngaita Coffee Factory
JMS1		light	
JMS2		light	JM Smucker
JMS3		medium	JM Smucker
JMS4		medium	JM Smucker
JMS5		dark	JM Smucker
JMS6		medium	JM Smucker
JMS7		medium	JM Smucker
JMS8		dark	JM Smucker
JMS9		medium	JM Smucker
Panama Los Cantares WB			Starbucks
Panama Carmen WB			Starbucks
Hawaii Kau WB			Starbucks
Roger Solis La Casona	Red Catuai	Full City; 395 F at 1st crack	Roger Solis (Sweet Maria's)
Finca El Regalito	Bourbon, Caturra	City +; 396 F at 1st crack	Aurelio Villatoro
Olam Specialty Coffee	Catimor, Typica	Medium	Olam Specialty Coffee
Amaro Gayo Natural	Ethiopian Heirloom Varieties	418	Asnakech Thomas
Tarazzu don Roberto	Caturra, Catuai	415	Many Small Producers
Brasil Natural Oberon	Mundo Novo, Catuai, Bourbon	420	Many Small Producers
Kenya AA Plus Nguvu	SL 28, Ruiru 11	410	Many Small Producers
Aleme Wako	Wolisho	Light Agtron 80	Aleme Wako
Idido Special Preparation -Lot 2	Kudhume, Wolisho, Peoa	Med Light Agtron 75	Idido Cooperative
Ngunguru	SL28, SL34, Ruiru 11	Agtron 72	Ngunguru Cooperative

Set 4:

COFFEE SAMPLES	ALTITUDE	DENSITY OF SOWING (mxm)
A	1500	1.20x1.30
B	1600	1,30X1,60
C	1300	1.5X1.3
D	1580	1.4X1.6
E	1500	1.60X1.40- 1.50X1.5
F	1400	1,4X1,4
G	1400	1.70X150
H	1800	1.4X1.4
I	1450	1.5X1-7
J	1400	1.50X1.40
K	1450	1.7X1.6
L	1700	1,3X1,6
M	1450	1,50X1,50, 1,5HA: 1,70X1,20
N	1600	1.30X1.70
O	1380	1.5X1.65
P	1120	1.40X1.30
Q	1450	1.20x1.60
R	1600	1,20X1,40
S	1800	1.4X1.7
T	1600	2X1,50

Appendix B - Ballot for Coffee Lexicon Development Research

AROMA

Roasted	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	**5**	5.5	6	6.5	7	**7.5**	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Burnt	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	**5**	5.5	6	6.5	7	**7.5**	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Acrid	0	0.5	1	1.5	2	2.5	**3**	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	**9.5**	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Smoky	0	0.5	1	1.5	2	2.5	3	**3.5**	4	4.5	5	5.5	**6**	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Ashy	0	0.5	1	1.5	2	**2.5**	3	3.5	**4**	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Woody	0	0.5	1	1.5	2	2.5	3	3.5	**4**	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Grain	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	**5**	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Malt	0	0.5	1	1.5	2	2.5	3	**3.5**	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Brown	0	0.5	1	1.5	2	2.5	**3**	3.5	4	4.5	5	5.5	**6**	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Spice Brown	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	**10.5**	11	11.5	12	12.5	13	13.5	14	14.5	15
Pepper	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	**13**	13.5	14	14.5	15
Pungent	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	**5**	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Sweet aromatics	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	**5**	5.5	6	6.5	**7**	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Brown sweet	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	**6**	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Caramelized	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	**7.5**	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Vanilla	0	0.5	1	1.5	2	**2.5**	3	3.5	4	4.5	5	**5.5**	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Honey	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	**6**	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Molasses	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	**6.5**	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15

Nutty	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	**7.5**	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Cocoa	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	**7.5**	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Chocolate	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	**8**	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Floral	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	**6**	6.5	7	7.5	**8**	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Fruity	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	**5.5**	6	6.5	**7**	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Fruity-Dark	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	**5**	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Fruity, Citrus	0	0.5	1	1.5	2	2.5	3	3.5	4	**4.5**	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Fruity, berry	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	**10**	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Fruity, non citrus	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	**6.5**	**7**	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Overripe	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	**6.5**	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Sour aromatics	0	0.5	1	1.5	**2**	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Green	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	**9**	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Green peapod	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	**7**	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Green herb-like	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	**6**	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Green hay-like	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	**7.5**	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Beany	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	**7**	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Tobacco	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	**7**	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Fermented	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	**7**	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Musty/Dusty	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	**10**	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Musty/Earthy	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	**9**	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15

Moldy/damp	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Stale	0	0.5	1	1.5	2	2.5	3	3.5	4	**4.5**	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Cardboard	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	**7.5**	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Rubber like	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	**5**	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Medicinal	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15

Flavor

Roasted	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	**5**	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Burnt	0	0.5	1	1.5	2	2.5	**3**	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Acrid	0	0.5	1	1.5	2	2.5	**3**	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Smoky	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	**5**	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Ashy	0	0.5	1	1.5	2	2.5	3	**3.5**	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Woody	0	0.5	1	1.5	2	2.5	3	3.5	**4**	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Grain	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	**8**	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Malt	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	**8**	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Brown	0	0.5	1	1.5	2	2.5	**3**	3.5	4	4.5	5	5.5	6	6.5	**7**	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Spice Brown	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	**10.5**	11	11.5	12	12.5	13	13.5	14	14.5	15
Pepper	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Sweet aromatics	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Brown sweet	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	**5**	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Caramelized	0	0.5	1	1.5	2	2.5	3	3.5	4	**4.5**	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15

Vanilla	0	0.5	1	1.5	2	2.5	**3**	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Honey	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	**6.5**	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Syrup (maple)	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	**5**	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Molasses	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	**6.5**	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Nutty	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	**7.5**	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Cocoa	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	**5**	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Chocolate	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	**7.5**	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Floral	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	**5**	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Fruity	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	**5**	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Fruity-Dark	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	**6**	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Fruity, Citrus	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	**6.5**	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Fruity, berry	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	**9**	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Fruity, non-citrus	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	**5.5**	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Overripe	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	**6.5**	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Green	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	**6**	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Green peapod	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Green herb-like	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	**5**	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Green hay-like	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	**7.5**	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Beany	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	**7.5**	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Tobacco	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Fermented	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15

Musty/Dusty	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Musty/Earthy	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Moldy/damp	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Stale	0	0.5	1	1.5	2	2.5	3	3.5	**4**	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Cardboard	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Astringent	0	0.5	1	**1.5**	2	**2.5**	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Metallic	0	0.5	1	**1.5**	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Bitter	0	0.5	1	1.5	**2**	2.5	3	**3.5**	4	4.5	**5**	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Sour	0	0.5	1	**1.5**	2	**2.5**	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Sweet	0	0.5	**1**	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15

Aftertaste

Bitter	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Astringent	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Sour	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15

Appendix C - SAS® codes for Descriptive Analysis of Coffee Samples

```
dm'log;clear;output;clear;';
Data (data name);
input Product$ Rep$ Code$ Panelist$ attr1 attr2 attr3 attr4 attr5 attr6 attr7 attr8 attr9 attr10 attr11 attr12 attr13
attr14 attr15 attr16 attr17 attr18 attr19 attr20 attr21 attr22 attr23 attr24 attr25 attr26 attr27 attr28 attr29 attr30
attr31 attr32 attr33 attr34 attr35 attr36 attr37 attr38 attr39 attr40 attr41 attr42 attr43 attr44 attr45 attr46 attr47
attr48 attr49 attr50;
datalines;
(input raw data here)
;
 ods rtf;

Proc means;
by Product;
var attr1—attr50;
run;

Proc glimmix;
class Product Rep Panelist;
model attr# = Product/ddfm=sat;
random rep panelist;
lsmeans Product/ pdiff lines;
title2 'Attribute Name';
run;

ods rtf close; quit;
```

Notes:

1. In the Proc Means statement, attr1 corresponds to the first attribute listed, and att50 corresponds to the last attribute listed.
2. The Proc Glimmix procedure is repeated for all the attributes

Appendix D - ANOVA Tables Scores for the Descriptive Analysis

Sample	Roasted (a)	Burnt (a)	Acrid (a)	Smoky (a)	Ashy (a)	Grain (a)	Pungent (a)	Petroleum (a)
S	6,48 ^{a}	3,96^{ab}	3,56^{ab}	1,80^{abcd}	3,12^{ab}	0,74^{bcde}	0.73^{b}	0.69^{abc}
Q	6,31 ^{ab}	3,76^{abc}	3,28^{bcde}	1,97^{ab}	2,80^{abcd}	0,68^{cde}	0.47^{bcd}	0.35^{bcde}
K	6,18 ^{abc}	3,86^{abc}	3,26^{bcde}	1,55^{bcdef}	2,57^{cdefg}	0,81^{abcde}	0.28^{cd}	0.39^{bcde}
B	6,11 ^{abcd}	2,66^{f}	2,39^{g}	1,45^{cdef}	2,22^{fg}	0,99^{abc}	0.33^{bcd}	0.44^{bcde}
M	6,07 ^{abcde}	3,52^{bcde}	3,02^{cdef}	1,86^{abc}	2,45^{defg}	0,94^{abc}	0.24^{d}	0.34^{bcde}
P	5,98 ^{abcde}	3,58^{abcd}	3,09^{bcdef}	1,63^{bcdef}	2,82^{abcd}	0,86^{abcd}	0.43^{bcd}	0.77^{ab}
N	5,98 ^{abcde}	3,56^{bcde}	3,09^{bcdef}	1,65^{bcdef}	2,75^{abcd}	0,89^{abc}	0.36^{bcd}	0.29^{cde}
R	5,98 ^{abcde}	3,86^{abc}	3,44^{abc}	1,98^{ab}	2,99^{abc}	0,49^{def}	0.70^{bc}	0.37^{bcde}
L	5,98 ^{abcde}	3,56^{bcde}	2,89^{defg}	1,45^{cdef}	2,67^{bcdef}	0,84^{abcde}	0.28^{cd}	0.59^{abcde}
C	5,95 ^{abcde}	3,48^{bcde}	3,07^{bcdef}	1,50^{cdef}	2,26^{fg}	1,07^{ab}	0.28^{cd}	0.26^{cde}
J	5,93 ^{abcde}	3,31^{cde}	2,91^{cdefg}	1,60^{bcdef}	2,65^{bcdefg}	0,79^{bcde}	0.33^{bcd}	0.39^{bcde}
T	5,91 ^{bcde}	4,13^{a}	3,86^{a}	2,18^{a}	3,20^{a}	0,46^{ef}	1.23^{a}	0.92^{a}
F	5,88 ^{bcde}	3,14^{def}	2,59^{fg}	1,31^{ef}	2,38^{defg}	0,83^{abcde}	0.38^{bcd}	0.69^{abc}
I	5,81 ^{bcde}	3,51^{bcde}	3,01^{cdef}	1,28^{f}	2,42^{defg}	1,04^{abc}	0.31^{bcd}	0.62^{abcd}
H	5,80 ^{bcde}	3,02^{ef}	2,60^{fg}	1,73^{abcde}	2,29^{efg}	0,99^{abc}	0.11^{d}	0.15^{e}
D	5,78 ^{bcde}	3,43^{bcde}	3,11^{bcdef}	1,43^{cdef}	2,80^{abcd}	1,09^{ab}	0.28^{cd}	0.27^{cde}
O	5,63 ^{cde}	3,66^{abcd}	3,34^{abcd}	1,85^{abc}	2,80^{abcd}	0,29^{f}	0.38^{bcd}	0.94^{a}
E	5,58 ^{de}	3,18^{def}	2,76^{efg}	1,45^{cdef}	2,42^{defg}	0,66^{cdef}	0.38^{bcd}	0.52^{abcde}
A	5,53 ^{ef}	3,01^{ef}	2,64^{fg}	1,65^{bcdef}	2,45^{defg}	1,19^{a}	0.11^{d}	0.22^{de}
G	4,99 ^{f}	3,12^{def}	2,86^{defg}	1,39^{def}	2,18^{g}	0,70^{bcde}	1.24^{a}	0.34^{bcde}
P-Value	*<0,0008*	*<.0001*	*<.0001*	*<0,0011*	*<.0001*	*0,003*	*<.0001*	*0.0086*

Sample	Roasted	Burnt	Acrid	Smoky	Ashy	Nutty	Sour aromatics	Dried Fruit
S	5,67^{ab}	4,83^{ab}	4,56^{ab}	1,90^{abcd}	4,53^{a}	0,52^{e}	2,38^{a}	0
Q	5,39^{abcdef}	4,30^{cde}	4,25^{bc}	1,88^{abcd}	3,68^{bcde}	1,00^{abcd}	2,15^{abcd}	0.59^{abcd}
K	4,99^{efg}	3,83^{defgh}	3,79^{cdef}	1,45^{defgh}	3,23^{efgh}	0,99^{abcd}	2,16^{abcd}	0.62^{abcd}
B	5,10^{cdefg}	2,91^{k}	2,79^{i}	1,20^{gh}	2,61^{i}	1,14^{abc}	1,91^{cdef}	0.89^{a}
M	5,38^{abcdef}	3,82^{defgh}	3,77^{cdef}	1,61^{bcdefgh}	3,46^{bcdefg}	0,84^{cde}	2,22^{abc}	0.44^{bcd}
P	5,75^{a}	4,33^{bcd}	4,19^{bc}	1,68^{bcdefgh}	3,88^{bc}	0,74^{de}	1,96^{bcdef}	0.44^{bcd}
N	5,50^{abcdef}	4,31^{bcd}	4,09^{bcd}	2,05^{abc}	3,76^{bcd}	1,17^{abc}	2,16^{abcd}	0.32^{cde}
R	5,55^{abcde}	4,66^{abc}	4,51^{ab}	2,13^{ab}	3,93^{b}	1,09^{abcd}	1,73^{ef}	0.32 ^{cde}
L	5,55^{abcde}	4,23^{cde}	4,11^{bcd}	1,83^{abcde}	3,71^{bcde}	1,17^{abc}	2,03^{abcde}	0.79^{ab}
C	5,14^{bcdefg}	3,24^{jk}	3,05^{hi}	1,26^{fgh}	2,88^{hi}	0,98^{abcd}	1,90^{cdef}	0.55^{abcd}
J	5,35^{abcdefg}	4,06^{def}	3,91^{cde}	1,68^{bcdefgh}	3,58^{bcdef}	0,99^{abcd}	1,98^{bcdef}	0.62^{abcd}
T	5,52^{abcde}	5,18^{a}	5,01a	2,33^{a}	4,61^{a}	0,82^{cde}	2,28^{ab}	0.24^{de}
F	4,79^{g}	3,60^{fghij}	3,43^{efgh}	1,38^{defgh}	3,05^{ghi}	0,83^{cde}	1,88^{cdef}	0.83^{ab}
I	5,65^{abc}	3,88^{defg}	3,84^{cde}	1,40^{defgh}	3,38^{cdefgh}	0,79^{cde}	2,01^{bcdef}	0.59^{abcd}
H	5,59^{abcd}	3,77^{efghi}	3,64^{defg}	1,77abcdef	3,11fghi	0,89^{bcde}	1,88^{cdef}	0.52^{abcd}
D	5,45^{abcdef}	3,28^{ijk}	3,29^{fghi}	1,25fgh	3,05fghi	1,34^{a}	1,66^{f}	0.59^{abcd}
O	5,47^{abcdef}	4,26^{cde}	4,16^{bcd}	1,70^{bcdefg}	3,33^{defgh}	0,94^{bcd}	1,98^{bcdef}	0.44^{bcd}
E	5,05^{defg}	3,36^{ghijk}	3,29^{fghi}	1,53^{cdefgh}	3,11fghi	1,12^{abcd}	1,83^{def}	0.72^{abc}
A	5,15^{bcdefg}	3,28^{ijk}	3,19^{ghi}	1,13h	2,96^{ghi}	1,27^{ab}	1,13^{g}	0.69^{abc}
G	4,94^{fg}	3,32^{hijk}	3,19^{ghi}	1,27^{efgh}	2,96^{ghi}	0,97^{abcd}	2,01^{bcdef}	0.73^{abc}
P-Value	*0,0231*	*.0001*	*.0001*	*.0001*	*.0001*	*0,0081*	*.0001*	*0.0104*

Sample	Astringent	Metallic	Bitter	Sour	Petroleum	Sweet Aromatics	Bitter (aft)	Sour (aft)	Astringent (aft)
S	3,54^{ab}	1,61^{abcd}	10,07^{a}	2,74^{a}	1,23^{abc}	0,07^{j}	10,31^{ab}	2,77^{ab}	3.54^{ab}
Q	3,42^{abcd}	1,72^{ab}	9,83^{ab}	2,68^{ab}	1,08^{bcde}	0,47^{fghi}	10,11^{abc}	2,70^{abcd}	3.42^{abcd}
K	3,36^{abcde}	1,54^{abcde}	9,15^{cdef}	2,54^{abcd}	1,13^{abcd}	0,62^{defgh}	9,26^{def}	2,55^{abcde}	3.36^{abcde}
B	2,74^{h}	1,16^{fgh}	8,40^{h}	2,29^{de}	0,45^{fgh}	0,99^{abcd}	8,5^{ghi}	2,22^{fgh}	2.74^{h}
M	3,38^{abcde}	1,61^{abcd}	9,26^{bcd}	2,62^{abc}	0,93^{bcdef}	0,65^{cdefgh}	9,39^{de}	2,76^{ab}	3.38^{abcde}
P	3,46^{abc}	1,71^{abc}	9,42^{bc}	2,64^{abc}	0,98^{bcdef}	0,47^{fghi}	9,74^{bcd}	2,77^{ab}	3.46^{abc}
N	3,34^{abcde}	1,66^{abcd}	9,40^{bc}	2,56^{abcd}	1,28^{abc}	0,59^{efgh}	9,71^{bcd}	2,72^{abc}	3.34^{abcde}
R	3,41^{abcd}	1,81^{a}	9,35^{bcd}	2,31^{de}	1,30^{abc}	0,29^{hij}	9,66^{bcd}	2,45^{cdefg}	3.41^{abcd}
L	3,16^{bcdefg}	1,49^{abcdef}	9,45^{bc}	2,54^{abcd}	1,15^{abcd}	0,62^{defgh}	9,39^{de}	2,62^{abcd}	3.16^{bcdefg}
C	2,86^{fgh}	1,07^{gh}	8,48^{gh}	2,19^{e}	0,36^{gh}	0,76^{bcdef}	8,38^{hi}	2,29^{efgh}	2.86^{fgh}
J	3,19^{bcdefg}	1,41^{bcdefg}	9,05^{cdefg}	2,48^{abcd}	0,85^{cdefg}	0,52^{fghi}	9,34^{de}	2,60^{abcd}	3.19^{bcdefg}
T	3,69^{a}	1,56^{abcde}	10,12^{a}	2,51^{abcd}	1,63^{a}	0,34^{ghij}	10,51^{a}	2,82^{a}	3.69^{a}
F	3,05^{defgh}	1,50^{abcdef}	8,60^{fgh}	2,40^{bcde}	0,89^{cdef}	1,02^{abc}	8,90^{efgh}	2,55^{abcde}	3.05^{defgh}
I	2,99^{efgh}	1,46^{abcdef}	9,07^{cdef}	2,54^{abcd}	0,83^{cdefg}	0,69^{cdefg}	9,19^{defg}	2,67^{abcd}	2.99^{efgh}
H	2,99^{efgh}	1,51^{abcdef}	9,11^{cdef}	2,41^{bcde}	0,64^{defgh}	0,75^{bcde}	9,29^{de}	2,53^{abcdef}	2.99^{efgh}
D	2,99^{efgh}	1,24^{efgh}	8,80^{defgh}	2,14^{ef}	0,55^{efgh}	1,14^{ab}	8,79^{efghi}	2,20^{gh}	2.99^{efgh}
O	3,24b^{cdef}	1,16^{fgh}	9,25^{bcd}	2,54^{abcd}	1,45^{ab}	0,17^{ij}	9,44^{cde}	2,60^{abcd}	3.24^{bcdef}
E	3,06^{cdefgh}	1,31^{defg}	8,65^{efgh}	2,36^{cde}	0,63^{defgh}	1,09^{ab}	8,59^{fghi}	2,47^{bcdefg}	3.06^{cdefgh}
A	2,81^{gh}	0,91^{h}	7,77^{i}	1,89^{f}	0,18^{h}	1,27^{a}	8,11^{i}	2,02^{h}	2.81^{gh}
G	2,99^{efgh}	1,35^{cdefg}	9,18^{cde}	2,44^{abcde}	0,56^{efgh}	0,99^{abcde}	9,07^{defg}	2,40^{defg}	2.99^{efgh}
P-Value	*.0001*	*.0001*	*.0001*	*.0001*	*.0001*	*.0001*	*.0001*	*.0001*	*.0001*

Appendix E - Ballot for Coffee Brewing Methods Research

AROMA

Roasted	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Burnt	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Acrid	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Smoky	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Ashy	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Brown	0	0.5	1	1.5	2	2.5	**3**	3.5	4	4.5	5	5.5	**6**	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Cocoa	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	**7.5**	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Chocolate	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15

Flavor

Roasted	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Burnt	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Acrid	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Smoky	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Ashy	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Woody	0	0.5	1	1.5	2	2.5	**3**	3.5	4	4.5	5	5.5	**6**	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Brown	0	0.5	1	1.5	2	2.5	**3**	3.5	4	4.5	5	5.5	**6**	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Cocoa	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	**7.5**	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15

Chocolate	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Astringen	0	0.5	1	1.5	2	2.5	**3**	3.5	4	4.5	5	5.5	**6**	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Bitter	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	**7.5**	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Sour	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15

Aftertaste

Bitter	0	0.5	1	1.5	**2**	2.5	3	**3.5**	4	4.5	**5**	5.5	6	**6.5**	7	7.5	8	**8.5**	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Astringen	0	0.5	1	**1.5**	2	**2.5**	3	**3.5**	4	4.5	**5**	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15
Sour	0	0.5	1	**1.5**	2	**2.5**	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15