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A COMPARISON OF CUPPING AND DESCRIPTIVE SENSORY ANALYSIS OF COLOMBIAN BREWED COFFEE

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ABSTRACT

Sensory profiles of thirteen coffee samples from the Huila Region, Colombia, were evaluated using two different sensory panels, a highly trained descriptive sensory panel and a group of certified coffee cuppers. The trained panel consisted of six descriptive panelists who developed a lexicon to evaluate and then test the coffee samples. Four 'cuppers' scored samples based on the Speciality Coffee Association of America "Cupping Protocol". In addition cuppers generated tasting notes to characterize the different coffee samples. Data analysis indicated little overlap between the two methods and a low relationship between the two different sets of terms. Moreover, tasting notes by cuppers indicate lack of agreements on the terms used to describe samples with only four terms used by more than two assessors to describe a single coffee product, out of a total of 59 terms used by the cuppers. The results indicate that the cupping method provides different information that cannot be used as an alternative to descriptive sensory analysis with trained panelists when describing the sensory profile of coffee products. Results also indicate that further training of cuppers is needed in order to potentially provide higher agreement in generating tasting notes to better characterize coffee samples.

INTRODUCTION

Coffee, after water, is the most popular beverage on earth. Factors such as the plant variety, the geographical areas where coffee is grown, climatic conditions, processing methods before the roasting phase, roasting level, grind size and brewing methods, participate in creating the different sensory properties existing from one product to another (Bhumiratana *et al*., 2010). The range of geographically different markets where this product is traded can be wide and the techniques through which coffee quality is defined by international and local institutions, as well as trading and private companies vary tremendously (Feria-Morales, 2002).

Trained panelists for descriptive analysis and expert tasters for flavor evaluation and quality control are commonly used by industries. Perceptive abilities such as the recognition of volatiles, can be enhanced in trained assessors or person that, having a reasonable sensory acuity and ability to focus their attention on specific sensory stimuli, are exposed to an appropriate series of products (Lawless, 1984).

Lawless categorize assessors that are not trained panelists in person having a longstanding experience with a specific product, more used for quality control, and persons who, as their profession, develop new products such as perfumers and flavor chemists.

Because of the shorter time required respect to instrumental methods and because it allows to determine coexisting characteristics, sensory analysis is most frequently used to estimate aroma, taste, and flavor of coffee brews (Nebesny and Budryn, 2006; Alvarado & Linnemann, 2010). In coffee beverages, the presence of several hundreds of volatile compounds can make drastically difficult to find the correlation between single substances and sensory attributes (Sanz *et al*., 2002).

Industries such as coffee, perfume, tea, and tobacco use 'experts' during the quality assessment process. This type of assessors can further be defined as persons that accumulate, year after year, wide knowledge about a specific product, and are involved in the decision-making process by companies (Gatchalian, 1981). Professional coffee judges are widely used all over the world. These experts can be very sensitive to any change in the characteristics of the product (Feria-Morales, 2002).

However, the use of experts for this scope cannot always be a proper and complete evaluation tool. Problems like bias, the influence of external factors, change in perceptiveness of the individuals, and the long time that can be necessary to develop this kind of professional figure, could discourage their use as sole evaluation tool. Totally different can be the case using trained sensory panelists, whose utilization is increasing, for example, for a detailed evaluation of the raw materials following to a rapid initial assessment by the experts (Feria-Morales, 2002).

It is possible to notice a different characteristics in the sensory vocabulary used depending on the level of training and experience of the assessors. Untrained people working in the coffee market have a larger vocabulary than consumers (Hayakawa *et al.*, 2010). At the same time expert coffee tasters like ‘cuppers’, trained to distinguish among small differences of coffee beverages, use a larger vocabulary than experienced untrained people. Conventional sensory analysis of coffee using well-trained panelists tends as well to evaluate intrinsic quality characteristic and descriptors, trying to deconstruct coffee flavor contrarily to a holistic perception (Narain *et al.*, 2003). To limit the number of attributes can be considered one important factor to optimize precision of sensory profiling.

The most used method, now as well as in the past to evaluate coffee quality in the cup is called 'cupping'. The grading system developed by the Speciality Coffee Association of America (SCAA) includes a list of standard attributes, such as Body and Acidity, to be scored in order to describe the product. However, one of the problems in coffee evaluation by expert 'cuppers' is the lack of a common language and a consistent vocabulary. This could help in better describing and comparing notes essential in discriminating among different coffee beverages beyond the main defects (Castle, 1986). This phase may be a critical point during quality assessment of the products.

Vocabularies (ICO, 2010) and handbooks (Castle, 1986; Lingle, 2001) have been developed to list terms that can describe sensory properties of coffee. Often these vocabularies focus on trying to develop terms influenced by specific cultural and linguistic aspects in order to be also recognized by local consumers of a given country (Hayakawa *et al.*, 2010; Seo *et al.*, 2009). This study wants to compare the sensory profile produced by a trained sensory panel, selecting a list of terms to describe the products, and 'cuppers' working for the coffee industry in Colombia, both working on the same coffee sample set. Objective of study was to verify the existence and the entity of eventual contact points between the results produced by the two different methods.

MATERIALS AND METHODS

Samples

Thirteen Arabica coffee beans samples hailing from Colombia, specifically from the Pitalito area in the Huila Region, were used in the study. Samples were subjected to a medium roasting. Products were obtained about 3 weeks before testing. Samples were stored in the Sensory Analysis Center at Kansas State University in sealed PVC non-permeable bags further contained in plastic box, at room temperature. Samples used for cupping method were evaluated directly within the coffee factory where they were processed, in a room dedicated to the evaluation. Within the Pitalito area, samples were from different sub-areas. Four samples originated from the Southern area, five samples from the Middle area, and 5 samples from the Northern area.

Sample Preparation

Descriptive Sensory Analysis

Medium roasted coffee beans were ground no more than 30 minutes before infusion. After an orientation session with the panel conducted for the scope, the amount of coffee used for the infusion preparation during the evaluation was established at 5.5 grams per 100 ml of water. This ratio is in accord with the International Standard for the preparation of coffee samples for use in sensory analysis (ISO 6668:2008) that suggest a ration included in a 5-9 grams range per 100 ml of water. Infusion was then allowed to stand for 3 minutes before being filtered through a metallic tea strainer.

Cupping Method

The tasting protocol followed the SCAA protocol (SCAA, 2009). Coffee samples were roasted within 24 hours of evaluation and allowed to rest for at least 8 hours and ground before the evaluation. Evaluation was conducted in a quiet environment, with no interfering aromas. Coffee beans were roasted to a medium roast level. The ratio used for the coffee beverage preparation was 8.25 grams of coffee per 150 ml of water. Coffee beans were ground no more than 30 minutes before the infusion with hot water. For sample uniformity evaluation, 5 cups of each sample were prepared. Clean and odor free water was used with an Ideal Dissolve Solids included in a 125 – 175 ppm range. Water was brought to approximately 92-94°C (200 °F) and poured directly on ground coffee. Grounds were steeped for 3-5 minutes before sample was evaluated.

Panelists

Descriptive Analysis

Six highly trained panelists from the Sensory Analysis Center, Kansas State University (Manhattan, KS) took part in this study. All of the panelists had completed 120 h of general descriptive analysis panel training with a wide range of different food products. Techniques and practice in attribute identification, terminology development, and intensity scoring, were part of the training. Panelists participating in the study had each more than 1,000 h of testing experience with a variety of food products. Further orientation focusing on coffee was provided to panelists, using samples included in the study as well as other different samples.

Cupping method

The four cuppers evaluating samples in this study were official cuppers with several years of experience in the Colombian coffee industry.

Terminology

Descriptive Sensory Analysis (Terminology Development)

Panelists were asked to develop a terminology based on the attributes present in the sample set object of the study. The terminology was developed for aroma, flavor, and aftertaste. During an initial phase several coffee samples, including samples not being part of the study, were showed to them. This step was considered necessary in order to conduct a preliminary orientation to the product category. All the samples object of study were showed to the panel during the terminology development stage. Different references were provided to the panelists. Some references were initially proposed by the panel members and researchers according to previous experience and studies. Other references were instead added during the terminology development phase.

A total of thirty 1.5 h sessions were held daily to establish, discuss and refine the attributes definitions to be included in the final terminology and the relative descriptive references. The goal of this phase was to try to avoid redundant attributes and overlapping among descriptive terms.

Cupping Method

The Cupping Form according to the SCAA Protocol includes terms considered important flavor attributes for coffee. Terms such as *Fragrance/Aroma, Flavor, Aftertaste, Acidity, Body, Balance, Uniformity, Clean Cup,* and *Sweetness* are considered positive scores of quality according to a rate by the cuppers. The attribute *Defects* reflects instead a negative score indicating unpleasant flavor sensations. The term *Overall* is scored according to the flavor experience of the individual cupper using their own personal appraisal.

Sample Evaluation Procedure

Descriptive Sensory Analysis

The samples were evaluated for aroma and flavor. Ten 2 h sessions were held for the evaluation stage. Three to four samples were evaluated during each session. A three-digit random code identified each sample and the order in which the samples were evaluated was randomized. To measure the intensity, a descriptive scale of 0-15 with 0.5 increments where 0 represents none and 15 extremely high, was applied. Each sample was individually evaluated by each panelist according with aroma and flavor references listed in the terminology previously developed. Three replicates were held for each of the thirteen samples. The coffee sample were transferred in thermos and brought into the panel room during the evaluation. The serving temperature was set in a range of 60 – 65 °C, according to the indication panelists gave during the orientation part about the temperature level working ideally for both aroma and flavor evaluation. Aroma evaluation was held first. Infusion were poured into Styrofoam cups with a volume of about 120 ml (4 oz.) filled for approximately ½ of the total volume. Panelists felt that the headspace in the cup filled with this amount was ideal for the aroma evaluation. At a later stage the flavor was evaluated. The same type of Styrofoam cups were filled again, filling approximately ¾ cup in order to have an adequate amount of sample to be tasted.

Cupping Method

According to the SCAA Protocol the scale used is a 16-point scale representing levels of quality from 6 to 9 with quarter point increments. In theory the scale ranges from a minimum of 0 to a maximum of 10. The cuppers evaluating in this study used in practice the 10 points score when they considered this necessary. A range from 6.00 to 6.75 is considered as Good, from 7.00 to 7.75 as Very Good, from 8.00 to 8.75 as Excellent, and from 9.00 to 9.75 (10.00 in this study) is considered Outstanding (SCAA, 2009).

Attributes were rated following a specific order according with the flavor perception changes caused by the decreasing temperature of the sample. *Fragrance/Aroma* was the first attribute to be evaluated. First, within 15 minutes after coffee beans were ground, the fragrance was evaluated. Later, after 3 minutes after infusing with water but no more than 5 minutes, the surface crust was broken and cuppers evaluated the aroma. Although cuppers can evaluate on the sheet these three steps separately, at the end a unique *Fragrance/Aroma* score on the sheet is required, reflecting both dry and wet evaluation. After about 10 minutes from infusion, when sample cools down at a temperature close to 70 °C (160 °F), *Flavor* and *Aftertaste* were evaluated. The reason because these attributes are evaluated at this time is because at this elevated temperature, the retro nasal vapors are at their maximum intensity. The procedure cuppers follow to do this consists in aspirate into the mouth in a way that permit to the liquid to cover as much area as possible, particularly the tongue and the upper palate. Next attributes that were evaluated, when the temperature continues to cool down (70 °C- 60 °C) were *Acidity, Body,* and *Balance.* The last attribute reflects how *Flavor, Aftertaste*, *Acid*ity, and *Body* fit together. Assessors repeat the evaluation of all the attributes above for further 2 or 3 times, while the temperature continues to decrease. When temperature reaches levels below 37 °C, Sweetness, Uniformity, and Clean Cup are evaluated. For these attributes each cup of the same sample is individually scored earning a maximum of 2 point per cup. When temperature reaches a temperature close to 20 °C (70 °F) the evaluation ends.

At this point the cupper gives an Overall score based on all the combined previously scored attributes. The final step consists in adding all the scores and detracting the eventual negative or poor flavors indicate as *Defects*. This scoring procedure follows peculiar rules described in the SCAA Protocols. Defects are classified in taints and faults. The first is an off-flavor noticeable but not overwhelming and it is given a “2” score in intensity. Faults are overwhelming off-flavors that can make the sample unpalatable. It is given a “4' as intensity score.

The Final Score are then given from the Total Score minus the Defects scores. It has a maximum of 100 and the score ranges has been classified having 90-100 indicating an outstanding product, 85-89.99 an excellent product, and 80-84.99 is considered a very good product. Coffee samples belonging to these three categories are indicated as ‘Speciality’. Sample earning a Total Score below 80 are considered ‘Not Speciality’.

Data Analysis

For principal component analysis (PCA), the Unscrambler version 10.2 (Camo Software AS, Oslo, Norway) was used. A PCA was conducted to analyze both results from cupping method and results from descriptive analysis. For descriptive analysis, a PCA was conducted for aroma and separately for flavor and aftertaste attributes scores. Most of the attributes receiving a score ≤ 1.0 were not included in the PCA. The Unscrambler version 10.2 software was also used for Partial Least Square Regression (PLSR) and Correlation analysis to compare cupping and descriptive analysis methods.

RESULTS AND DISCUSSION

Terminology

Descriptive Terminology Development

At the end of the terminology development sessions, a total of 92 terms was generated. On all the terms a final agreement among panelists existed. Forty-three attributes were related to aroma, forty-six to flavor, and three to aftertaste. To reach consistency during the following evaluation phase, it was decided to use only a narrow group of aftertaste attributes that panelist detected in all the samples objective of study. For each attribute, definitions and references were generated (data not shown). All the attributes are listed in Table 1.

Some aroma attributes such as Pepper, Honey, Molasses, Fruity citrus, Fruity berry, Green herb-like, and Fermented were detected only in three or less samples up to thirteen. For flavor attributes detected in three or less samples were Pepper, Honey, and Syrup.

Cupping terminology

In addition to the standard attributes from the SCAA Protocols, the cuppers evaluating in this study, were asked to generate for each sample a group of tasting notes that could describe and differentiate each specific product from the others. These terms are shown in Table 2. It is possible to notice as an extremely high inconsistency level among cuppers' notes. On a total of fifty-nine tasting notes, only four were used by more than two assessors for a specific sample. This inconsistency can be explained by a lack of discussion and agreement on common definitions related to the terms.

Principal Component Analysis

Descriptive analysis

For aroma, attributes Malt, Spice brown, Pepper, Pungent, Brown sweet, Caramelized, Vanilla, Honey, Molasses, Chocolate, Floral, Fruity, Fruity dark, Fruity citrus, Fruity non citrus, Fruity berry, Overripe near fermented, Green, Green pea pod, Green herb-like, Fermented, Musty earthy, Moldy damp, Stale, Rubber like, and Medicinal earned scores ≤ 1.0 for all of the samples (data not shown). For flavor the attributes earning a score ≤ 1.0 were Malt, Spice brown, Pepper, Brown sweet, Caramelized, Vanilla, Honey, Syrup, Molasses, Chocolate, Floral, Fruity dark, Fruity citrus, Fruity berry, Fruity non citrus, Overripe near fermented, Raw, Green pea pod, Green herb-like, Green hay-like, Fermented, Musty earthy, Moldy damp, Stale, and Sweet. These attributes were not included in the PCA analysis except for Musty earthy and Metallic that showed, for flavor, a significant difference (p-value < 0.05) among the different samples. To have consistency Musty earthy was kept in the PCA analysis for aroma too.

Principal component analysis plots related to aroma attributes are shown in Figure 1 and 2. Factors 1-4 explained together 80.71% of the variability. Factor 1 explained 36.16% of the variability and was positively loaded with Acrid, Ashy, and Burnt aroma and negatively loaded with Grain, Sweet aromatics and Nutty aroma attributes. Factor 2 explained 25.91% of the variability and was positively loaded with attributes like Grain, Cocoa, and Sweet aromatics, and negatively loaded with Sour aromatics and Cardboard. Factor 3, explaining 10.80% of the variability, was positively related to Musty/Earthy note. Factor 4 explained 7.85% of variability and was positively related to Cardboard aroma and negatively with Nutty, Roasted, and Burnt aroma notes. In Figure 1 is possible to observe sample SZ331 (south area of the region) placed in an area positively loaded with factor 1. On the other side of the plot, related to attributes such as Grain and Nutty, was located sample ZM322. However, the scores related to these attributes were < 2 points scale (data not shown).

For flavor and aftertaste, principal components analysis plots are shown in Figure 3 and 4. Factor 1-4 explained together 87.72% of the variability. Factor 1 explained 49.56% of the variability and was positively loaded with several attributes such as Acrid, Burnt, Ashy, Bitter flavor and Bitter aftertaste attributes and negatively with Sweet aromatics. Factor 2 explaining 23.25% of the variability, was positively loaded with Bitter aftertaste and negatively loaded with Smoky and Ashy flavor notes. Factor 3 explained 8.18% of the variability and was positively related with Bitter. Factor 4, explaining 6.73% of the variability was positively loaded with Musty earthy attribute and negatively with Musty dusty. In Figure 3, related to Factor 1 and 2, it is possible to notice as for flavor, due to the low variation among samples, attributes tend to be grouped and not spread in the plot except for Bitter aftertaste. Two samples, coming from the middle area of the region of interest (ZM334) and another coming from the north area (ZN326), were placed in the area of the plot close to Bitter aftertaste separated from the most of the samples. Other samples distant from the center of the plot were ZM322, ZM327, and ZS335, placed closer to Sweet aromatics attributes. Sample ZS331 was located in the area of the plot negatively loaded with factor 2.

Cupping

Principal component analysis for cupping evaluation results is shown in Figure 5 and Figure 6. Factor 1-4 explained together 89.85% of the variability within the samples. Factor 1 explained 42.57% of the variability and was positively loaded mostly with Balance attributes. It is possible to notice as all of the attributes are grouped in an area positively related to Factor 1, excepting for Uniformity. This, similarly to the results gathered from descriptive analysis for Flavor, can indicate the low variability among samples. Factor 2 explained 23.99% of the variability, was positively related with Uniformity. Figure 5 shows as samples are spread distant from the area where the attributes are grouped with sample ZS335 located in an area of the plot negatively loaded with factor 1 and sample ZM334 placed in an area negatively loaded with factor 2. Factor 3, explaining 15.76% of the variability was positively loaded with Balance and negatively with Acidity. Factor 4, explaining 7.53 of the variability was positively related to attributes like Clean cup and Fragrance/Aroma. In Figure 6 is possible to notice as the attributes are spread to the margins of the plot with several samples closer to the center and others close to attributes such as Acidity, Aftertaste, and Body.

Partial Least Square Regression and Correlation Analysis

In the PLSR cupping method scores (x) were compared with descriptive analysis scores (y). The related plot is shown in Figure 7. Observing the plot it is possible to notice as, excepting for some overlapping areas, the two set of attributes used in the two methods are quiet distinct and do not show a particular correlation. Similarly to what observed from the PCA for cupping, Uniformity (cupping) is the only attribute that do not group with the others from the same method. Some overlapping can be observed between the cupping attributes and descriptive aroma attributes such as Cocoa, Grain, Nutty, and Sweet aromatics as well as flavor attributes like Musty Dusty, Woody, and Roasted.

Correlation analysis indicated a positive correlation (r = 0.66) between Grain aroma (descriptive) and Fragrance/Aroma (cupping), and negative correlations between Sour Aromatics (descriptive) and Fragrance/Aroma (cupping) (r = - 0.77), and Musty/Earthy flavor (descriptive) and Aftertaste (cupping) (r = - 0.66).

It is possible to notice as Fragrance/Aroma from cupping method and Grain from descriptive were close in the PLSR plot too. Although other attributes such as Cocoa aroma were close to Fragrance/Aroma in the plot has to be highlighted that most of them earned scores below 1.0 in all of the samples from descriptive analysis. Thus, stating that there a correlation between this attributes and Fragrance aroma (cupping) cannot be correct. Moreover is noticeable like the Uniformity cupping term is far from the other terms from the same methods, all grouped together in an area of the plot.

Observing Figure 6 relative to Cupping PCA is possible to notice as samples ZM334 and ZN326, negatively loaded with factor 2 characterized by a positive loading with Uniformity, are the same samples that in the descriptive analysis PCA plots is placed in an area close to Bitter aftertaste (Figure 3) positively loaded with factor 2.

CONCLUSIONS

Thirteen coffee samples from coffee bean cultivated in the Huila Region (Colombia) were evaluated both by a team of experts, 'cuppers', widely used from coffee industry for the quality assessment, and by a trained sensory panel. A list of term was generated by sensory panelist to describe the samples. The attributes indicated in the Cupping SCAA Protocols were scored for the cupping methods. The comparison between the two methods results showed as low correlation exists. Partial Least Square Regression analysis showed as few points of contact exist among the attributes coming from the two different methods. Moreover, PCA indicate as cupping terms are close each other, and far from samples, indicating that probably the method is not capturing entirely the samples profile. Instead, it seemed like descriptive analysis terms, especially for aroma, better described the samples, capturing better the variation among terms and samples characteristics. This study was intended to be a preliminary step for a future work leading in better integration between the 'experts' evaluation and descriptive sensory analysis related to coffee.

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TABLE 1. DESCRIPTORS GENERATED BY DESCRIPTIVE SENSORY ANALYSIS PANEL.

Category	**Descriptor**		
Aroma and Flavor	Roasted	Vanilla	Green
	Burnt	Honey	Green, Peapod
	Acrid	Molasses	Green, Hay-like
	Smoky	Nutty	Green, Herb-like
	Ashy	Cocoa	Beany
	Woody	Chocolate	Tobacco
	Grain	Floral	Fermented
	Malt	Fruity	Musty/Dusty
	Brown	Fruity, Dark	Musty/Earthy
	Spice Brown	Fruity, Citrus	Moldy/Damp
	Pepper	Fruity, Berry	Stale
	Sweet Aromatics	Fruity, Non citrus	Cardboard
	Brown Sweet	Overripe/near Fermented	Caramelized
Aroma	Pungent	Sour Aromatics	Rubber-like
	Medicinal		
Flavor	Syrup (Maple)	Raw	Astringent
	Metallic	Bitter	Sour
	Sweet		

Aftertaste	Bitter	Astringent	Sour

TABLE 2. TASTING NOTES GENERATED BY CUPPERS TO CHARACTERIZE THE SAMPLES. NOTES ARE DIVIDED ACCORDING TO THE MAXIMUM NUMBER OF ASSESSORS USING THE NOTE TO DESCRIBE A SINGLE SAMPLE (ON A TOTAL OF FOUR EVALUATING CUPPERS).

Used by 3 cuppers	**Used by 2 cuppers**	**Used by 1 cupper**		
Citric	Fruit	Sweet Fruit	Fresh	Red Wine
Sweet	Yellow Fruit (peach, mango, papaya)	Mango	Coffee Skin	Mild Tobacco
Candy	Red Fruits (strawberry, cherry)	Fresh Lemon	Lasting	Bitter Tobacco
Malt	Honey	Lime	Sand Flavor	Aftertaste Tobacco
	Sugar cane	Fresh Fruits	Land Flavor	Roast Malt
	Grass	Raisin Grape	Wood	Medium Acidity
	Rough	Mandarin	Short Astringent	Cardboard
	Chocolate	Mild Coffee	Fresh Astringent	Smoke
	Nut	Bitter Chocolate	Low Astringent	Watermelon
	Hazelnut	Cocoa	Strong	Uniformity
	Flower	Creamy	Short Body	Cinnamon
	Astringent	Creamy Body	Good Body	Vanilla
	Strong Body	Roast Nut	Consistent	Syrup
	Balance	Peanut	Wine	

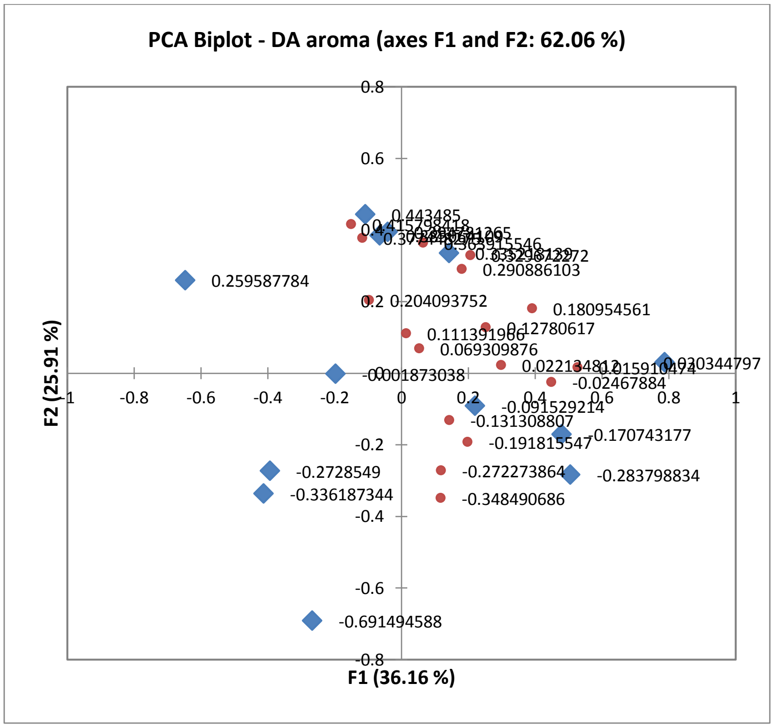

Figure 1. PCs 1 and 2 loading plot (aroma)

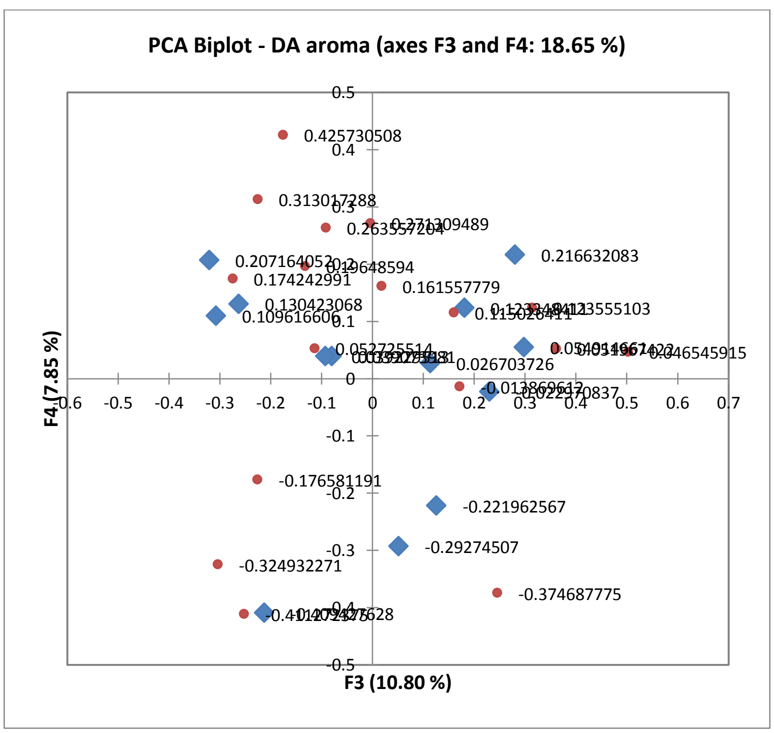

Figure 2. PCs 3 and 4 loading plot (aroma)

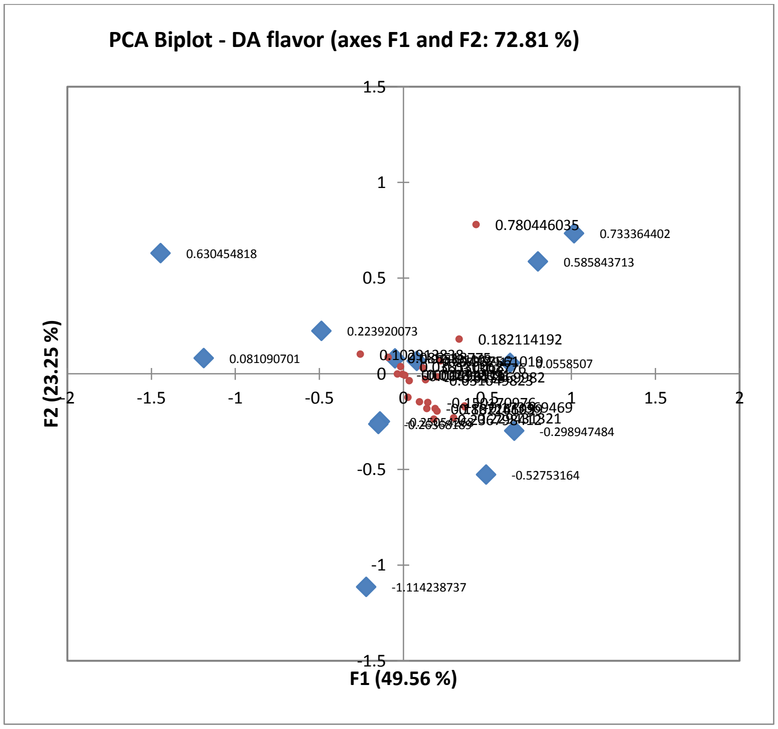

Figure 3. PCs 1 and 2 loading plot (flavor and aftertaste)

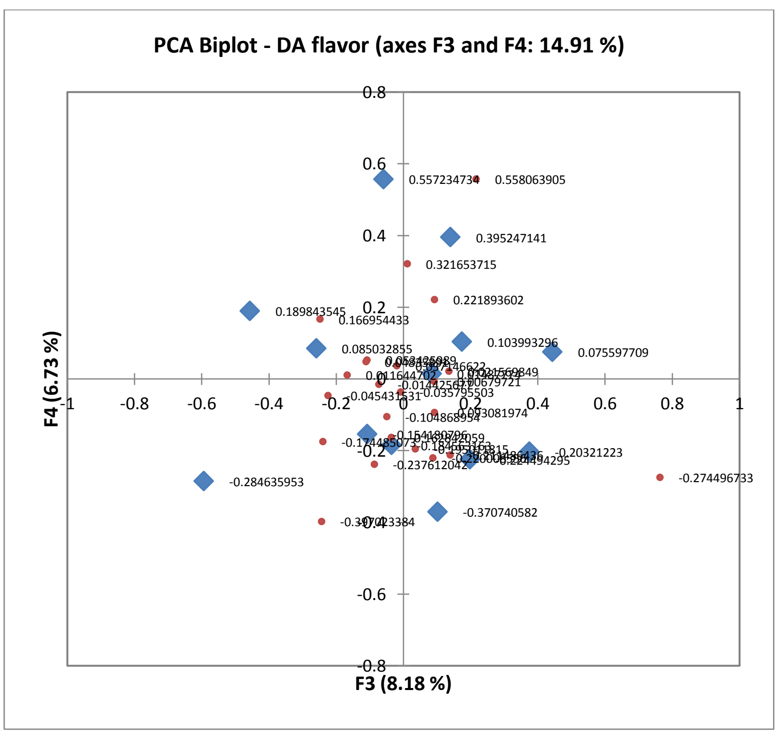

Figure 4. PCs 3 and 4 loading plot (flavor and aftertaste)

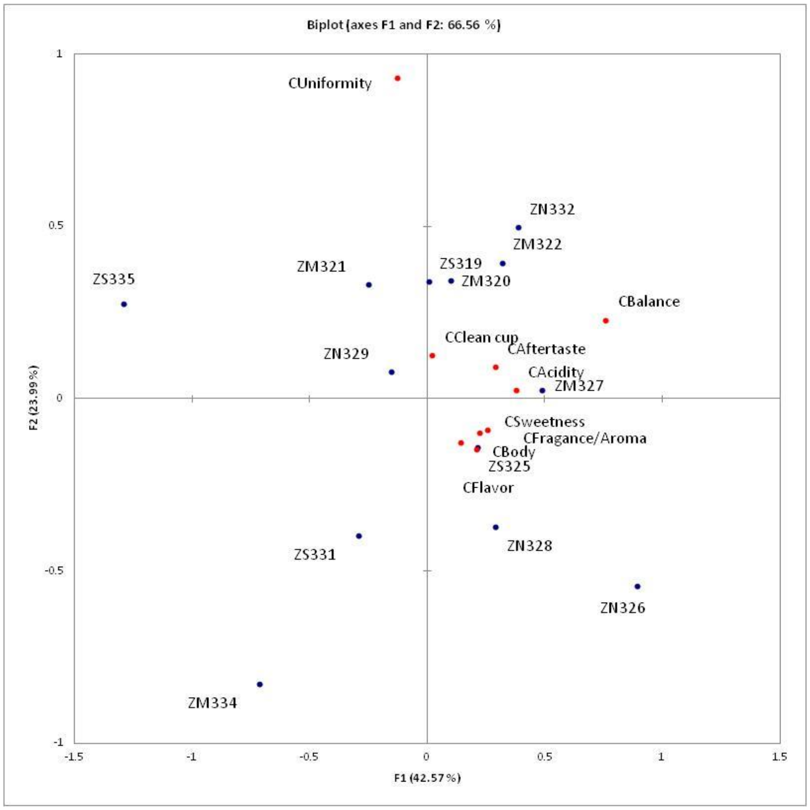

Figure 5. PCs 1 and 2 loading plot (Cupping)

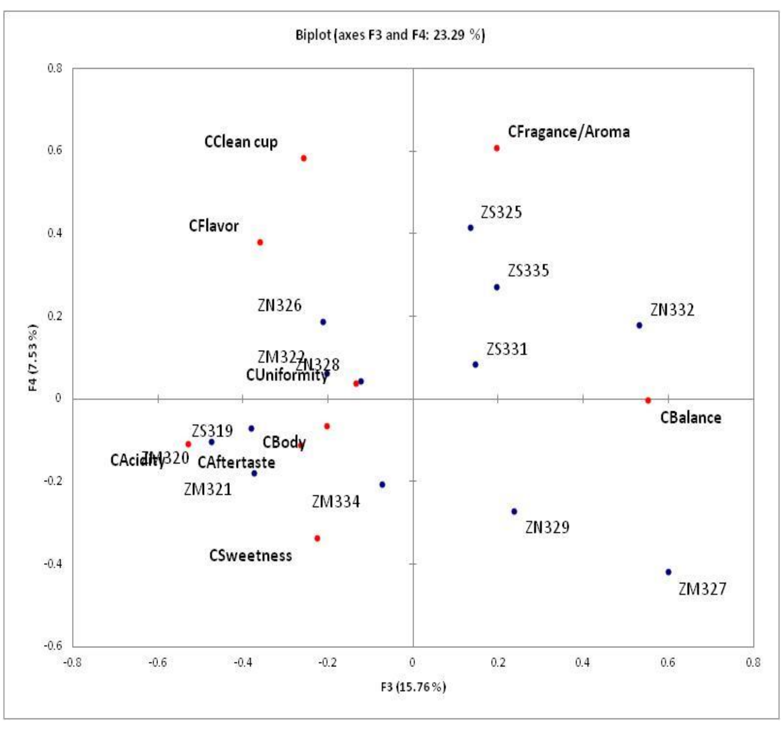

Figure 6. PCs 3 and 4 loading plot (Cupping)

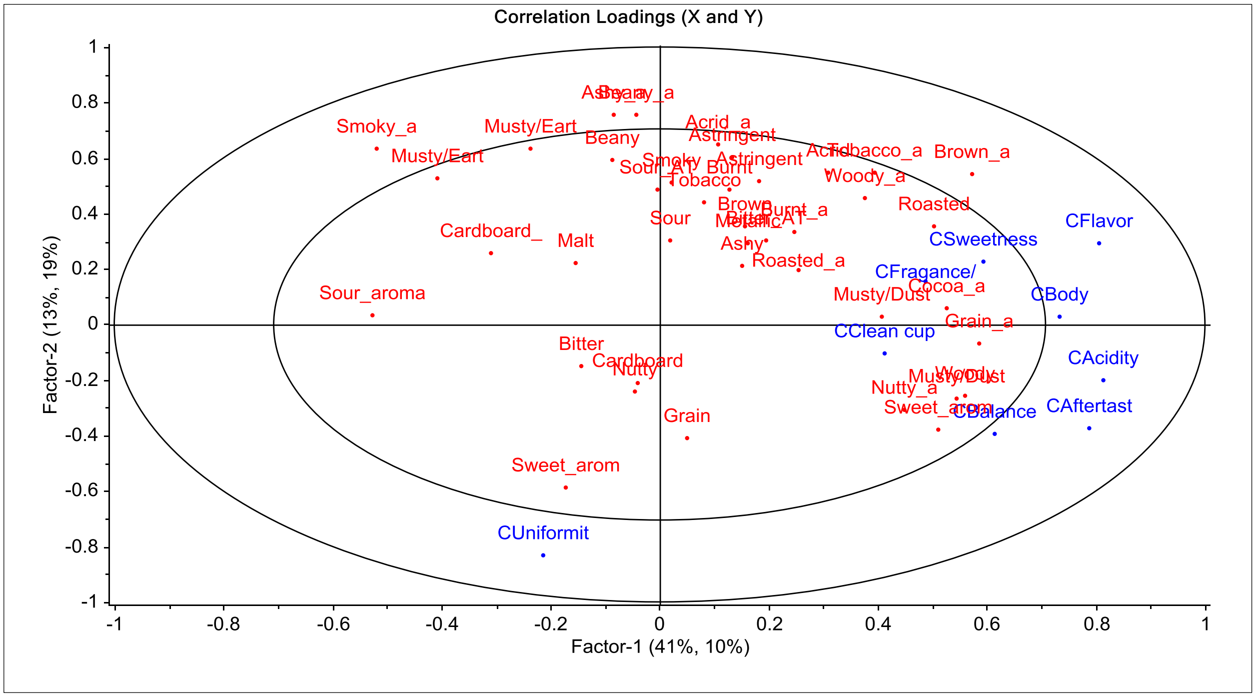

Figure 7. PLSR Analysis – cupping methods scores (x), descriptive analysis scores (y).