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Evolution of sensory aroma attributes from coffee beans to brewed coffee

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ABSTRACT

This study investigated the impact of degree of roasting, grinding, and brewing on the evolution of coffee aroma in green coffee beans from Ethiopia, Hawaii, and El Salvador. Using a highly-trained descriptive panel, 15 aromatic sensory attributes were identified and quantified in green beans, roasted beans (light, medium, and dark), ground coffee, and brewed coffee. Analysis of variance (ANOVA) and principal components analysis (PCA) were done separately for each preparation stage/step. The ANOVA showed that green beans had low coffee-related characteristics and were high in beany, green, musty/earthy, and sour aromatics, all of which carried through to the final brews. In general, the light roast was perceived to be sweeter in all stages and the darker roasts attained higher intensity of the typical 'coffee' attributes with which coffee consumers might like (coffee, roasted, burnt/acrid, and ashy/sooty). The aroma profiles generated were more influenced by the preparation stages and degrees of roasting than the coffee varieties.

1. Introduction

Odello and Lavaroni (2009) showed evidence that consumers are interested in 'pure' coffee or coffee of a single origin. Although they found that consumers were unable to distinguish coffee blends from single origin coffees, they seemed to have a substantial interest in single origin coffee. In order to understand whether this consumption trend towards single origin coffees is based on real differences in sensory aspects of coffees or is more related to other perceptual issues, the industry needs to investigate the sensory characteristics of this so-called 'pure' coffee to develop a better understanding of this product category.

Aromatic components are particularly important in coffee beverages as they are the main constituents of the sensory experience of coffee drinkers. Illy and Viani (2005) summarized that there are six factors that affect the sensory properties of coffee: plant varieties, growing region/conditions, processing methods (from coffee cherries to green coffee bean), roasting levels, grinding size, and brewing methods. Extensive studies have been conducted since the beginning of 1900s to discover the volatile compounds responsible for coffee aroma and flavor in roasted bean, ground coffee, and brewed coffee (Czerny, Mayer, & Grosch, 1999; Sarrazin, Le Quere, Gretch, & Liardon, 2000; Semmelroch & Grosch, 1996). Many studies have investigated the impact of coffee origin, degree of roasting and roasting time and temperature combinations on the formation of volatile compounds responsible for the coffee flavors and aromas (Baggenstoss, Poisson, Kaegi, Perren, & Escher, 2008; Mayer, Czerny, & Grosch, 1999; Schenker et al., 2002). However, finding the relation between the content of the hundreds of volatile compounds present in coffee and the complex aroma of coffee is not an easy task (Nebesny & Budryn, 2006). Sensory analysis has become a useful tool for quality assessment of coffee beans and brews. A few previous studies have evaluated some of the sensory attributes and overall acceptability of roasted coffee beans and brewed coffee with the intent of examining the effect of growing environments, coffee varieties, roasting methods and conditions, degrees of roasting, and storage conditions on these coffees (Decazy et al., 2003; Nebesny & Budryn, 2006; Ross, Pecka, & Weller, 2006).

However, no sensory research was found on the development of aroma in each stage of preparation, starting from green coffee bean to brewed coffee. This gap in research should be investigated because 1) each stage plays a significant role in the development of coffee aroma during the coffee brewing process, 2) sensory characteristics need to be identified and quantified because not all the present volatile compounds in a substance are perceived by humans. The concentration of a given compound must exceed the recognition threshold level in order to trigger the receptor response in the brain to generate an image of the aroma (Czerny et al., 2008; Grosch, 1998).

Green coffee beans are the raw material of coffee. The green beans contain the precursors of aroma volatiles that are developed

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during the roasting process. Different coffee varieties, growing conditions, and processing methods contribute to the distinctive aromatic compounds unique to each type/origin of green coffee. Although the aroma and flavors are characterized by the origin of green coffee, the roasting process controls the developmental progress of the volatile compounds, resulting in differences in complexity of coffee aroma with different roast degrees and conditions. In general, roasting ruptures the cell structure of the green coffee beans, exposing it to heat that drives out the moisture and releases the aromatic compounds that have been chemically bound in the beans. Starch in the bean converts to sugar and starts to caramelize as moisture escapes. Once the bean is heated to 205 °C, pyrolysis (thermal decomposition and chemical change) occurs. Carbon dioxide, aldehydes, ketones, ethers, acetic acid, methanol, oils, and glycerol are volatilized from the bean. Different volatile compounds break down at different temperatures, and as pyrolysis continues, the flavor and aroma of the coffee bean continue to develop and degrade (Illy & Viani, 2005; Sivetz & Desrosier, 1979; Yeretzian, Jordan, Badoud, & Lindinger, 2002). Grinding of roasted coffee beans is a method used to release the developed coffee aromatic compounds and brewing extracts the aromatic compounds from ground coffee into the final drink. A specific grind size is appropriate to certain brewing methods (Illy & Viani, 2005; Sivetz & Desrosier, 1979).

Not much work has been reported on evolution of aroma attributes from the green coffee bean stage to the brewed coffee stage. All forms of coffee are available in the retail for consumer purchase in the form of green coffee bean, whole roasted coffee bean, ground coffee, and brewed coffee drinks. Because coffee aroma is the major factor in purchase decision, it is crucial that the industry be able to understand the aroma attributes present in each stage, and also how the attributes develop during the process of making the coffee drink. The major objective of our study was to identify the change in aroma characteristics as a result of roasting, grinding and brewing processes in three coffee bean varieties. The effect of bean origin (El Salvador, Hawaii and Ethiopia) and levels of roast (light, medium and dark) on the evolution of aroma attributes were also studied.

2. Materials and methods

2.1. Coffee samples

Wet-processed green Arabica coffee varieties from three countries of origin were used to represent different single origin coffee varieties from different wet-processed Arabica coffee producing regions. The coffee beans selected are Hawaii Kona Lehuula Farm Typica, Ethiopia Organic Wet-process Kebado, and El Salvador Siberia Estate Bourbon. All the green coffee samples were purchased from Sweet Maria's Home Roasting website (http://www.sweetmarias.com/index.php).

2.2. Sample preparation and serving

The amount of coffee sample to be evaluated is determined according to the brewing standard of Specialty Coffee Association of America (SCAA). For a standard 100 mL cup of brewed coffee, 4.9 g of ground coffee is recommended by the SCAA. Therefore, 4.9 g of each sample of green coffee, roasted coffee, and ground coffee and 100 mL of each sample of brewed coffee were presented to the panelists in a 414-mL glass snifter covered with a watch glass. The panelists cleansed their nasal passages between each sample by breathing through a warm clean cotton washcloth filter.

2.2.1. Roasting

Preliminary testing was done to assess the appropriate roasting time and temperature for each roast level (data not included). Each green coffee sample was roasted in a Hearthware i-Roast2 home coffee roaster (Model No. 40011; Hearthware Inc., Gurnee, IL, USA) to create light, medium, and dark roasts (Baggenstoss et al., 2008; Illy & Viani, 2005; Owen, 2009; Schenker et al., 2002; Sivetz & Desrosier, 1979; Yeretzian et al., 2002). The roaster was programmed to consist of 3 consecutive roasting temperature/time combinations to produce the assigned degree of roasting. For the light roast, coffee beans were roasted at 180 °C for 3 min and 30 s and 205 °C for 3 min. For the medium roast, coffee beans were roasted at 180 °C for 3 min and 30 s.; 205 °C for 4 min; and 238 °C for 10 s. For the dark roast, coffee beans were roasted at 180 °C for 3 min and 30 s.; 205 °C for 4 min; and 238 °C for 1 min. Once the roasting process was terminated, cool air was immediately blown into the chamber for 4 min to cool down the roasted beans. The roasted coffee was then removed from the roaster and placed in a metal container to cool until it reached room temperature (22 ± 2 °C). The roasted samples were stored in 110-mL clear, stand up, odor-free, zippered plastic bags with a CO_2 de-gassing valve, also purchased from Sweet Maria's. All samples were allowed to rest for at least 24 h prior to testing.

2.2.2. Grinding

Ground coffee samples were prepared by grinding 30 g of roasted beans in a Black & Decker SmartGrind Model CBG5 coffee bean grinder (The Black & Decker Corporation, Towson, MD, USA) for 10 s. The tested samples were ground the day of testing and not more than 30 min prior to the evaluation to ensure freshness (Sivetz & Desrosier, 1979).

2.2.3. Brewing

Seven-hundred and twenty milliliters of reverse osmosis, deionized, carbon filtered water was heated to 90 °C and poured over an appropriate amount (35 g) of freshly ground coffee in a Chemex Model CM-6A coffee brewer (Chemex® Corp, Pittsfield, MA, USA). The hot water was poured evenly on the ground coffee through a Chemex® bonded unbleached coffee filter, and 100 mL was immediately poured into each snifter and served to the panelists at approximately 70 °C.

2.3. Descriptive analysis

A panel consisting of six highly-trained descriptive members (1 male and 5 females; age range 50–70 years) from the Sensory Analysis Center at Kansas State University evaluated the coffee samples. The panelists had completed 120 h of general training and had a minimum of 1200 h of general sensory testing including beverages and other food products. Three 90 min orientation sessions were conducted to familiarize the panelists with the evaluation process and the samples to be tested. Three coffee samples from each stage, except for brewed coffee, were randomly selected to be examined in the first two orientation sessions. The last session was focused on six randomly selected brewed samples. The coffee beans needed for the orientation sessions were roasted 1–2 days prior to the sessions. During orientation, the descriptive panel developed a list of aromatic attributes for the study. A list of 15 appropriate aroma descriptors and their definitions was generated for the samples. The list of descriptors is shown in Table 1. The references needed for each attribute were also determined to calibrate the intensity measurement.

Two replications of each sample were evaluated in this study and were presented monadically and coded with 3-digit random numbers. A total of 30 coffee samples were evaluated for each