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308 Lasani Town, Sargodha Road, Faisalabad - Pakistan
Mob: +92 300 3008585, Fax: +92 41 8815544
E-mail: editorpjn@gmail.com

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Exploration Study of Gayo Specialty Coffee (*Coffea arabica* L.): Chemical Compounds, Sensory Profile and Physical Appearance

Murna Muzaifa and Dian Hasni
Department of Agricultural Product Technology, Agricultural Faculty, Syiah Kuala University,
Jl. Tgk Hasan Krueng Kalee 3 Darussalam 23111, Indonesia

Abstract: Arabica coffee considers as premium export commodity from Indonesia. Nowadays, Gayo Arabica coffee is known as specialty coffee from single origin-Gayo Highland areas Centre Aceh Indonesia. As niche market, coffee specialty points out different bottom lines where cupping quality plays the main role. Cupping quality counts as total score of ten attributes namely as fragrance, flavor, aftertaste, acidity, body, balance, uniformity, clan cups, sweetness and overall. This study aims to explore the quality of four types of popular Gayo Arabica coffee which are regular Arabica, wild palm civet, cultivated palm civet and natural. Sensory properties and physical appearance was examined by Gayo Cupper Team as Q-grader based on specialty coffee standards. Chemical compounds include moisture, crude protein, fat, ash contents were also analyzed. Results showed wild palm civet and Arabica regular considers as specialty coffee, which have highest cupping test score respectively 85.75 and 83.25, uniformity bean size were 71.5% in size of <16" for wild palm civet, 49.1% in size of >19" for Arabica regular, greenish color; quackery beans lev. 1 for wild palm civet and green yellow; quackery beans lev. 3 for Arabica regular. Chemical compounds demonstrated that wild palm civet (12.55%) and Arabica regular (11.63%) also respectively fulfilled moisture contents of specialty coffee standard (9-13%), whereas Arabica regular showed as coffee with lowest content of fat from others. The study concluded processing techniques majorly affects of bean chemical compounds where also coherently affect the cupping quality of bean itself.

Key words: Cupping test, wild palm civet coffee, Arabica, Gayo, specialty coffee

INTRODUCTION

As a very popular brewed beverage, the demand for coffee in international market steadily increased and counted as the second important agricultural commodity after petroleum (ICO, 2011a). Not only that, new paradigm of coffee as benefit for health, sustainability production as well as the fair prices for coffee farmers also bring extrinsic economics value for coffee (Farah, 2010). One of niche market of coffee is coffee specialty from single origins, which nowadays is one of favorite choices of most of coffee consumers came from the USA, Germany, Japan, Italy and France (ICO, 2014).

The terms "specialty coffee" was firstly introduced by Erna Knutsen in 1978, described as coffee produced in special geographic and being perfectly suitable for producing coffee beans with unique flavor profiles. This concept then adopted Specialty Coffee Association which continually defines coffee specialty as a brewed drink which highly dependent on its quality throughout the supply chain which in facts influenced by complex of intermediaries and involving many actors from farmers until barista. And then, the next contributors of specialty coffee are placed on its preservation and revelation. Coffee preservation refers to suitable climate condition, coffee varieties and farm management practices. Gayo Arabica coffee plants in soil which has primarily *Andosols*, well managed farms with good pruning and shade grown system, healthy plant with manual harvesting when the cherries are fully ripe, not before. On the other hand, coffee revelation covers the processing steps both in the field area and the transformation process from green to roasted coffee. In Aceh, farmers and producers apply the unique wet hulling system producing coffee with heavy body, less acidity and high level of spicy flavor, as the key feature Aceh Coffee is famous for (SCAA, 2009; SCAI, 2011; Maier, 2005; Bina UKM, 2010).

Palm civet coffee or *Kopi luwak* is claimed as the world most expensive coffee with price of U.S. $150-227/pound (Onishi, 2013). Palm civet coffee is produced from coffee berries that have been consumed by the Asian pam civet (*Paradoxurushermaphroditus*) that lives wild or cultivated. The civet climbs coffee trees and instinctively selects coffee cherries. During digestion, the coffee pulp is completely digested and the beans are excreted (Joshi *et al*.,1995). The intact beans are then collected, cleaned, wet fermented, sun-dried and further processed by roasting. Palm civet coffee's high selling

Corresponding Author: Murna Muzaifa, Department of Agricultural Product Technology, Agricultural Faculty, Syiah Kuala University, Jl. Tgk Hasan Krueng Kalee 3 Darussalam 23111, Indonesia

price is mainly attributed to its exotic and unexpected production process (Marcone, 2004). On the other hand, natural is old-time coffee processing which common practiced in Gayo Highland, but nowadays it comes as renewal method of coffee processing in Gayo Highland which similar-alike natural processing of Brazilian coffee, where combining both dry and wet methods. The method consists of washing and selection of the seeds in flotation tanks without fermentation (Farah, 2012).

After introduced by The Dutch colony in 1924, Arabica coffee became premium commodity from Gayo Highland since that time (AICE East Java, 2011; ICO, 2011b). Nowadays there are several kinds of Gayo coffee that have been known globally due its superior quality. As specialty coffee brings higher economic value, many attempts constructed to claim produced coffee as specialty coffee, therefore this research investigated the chemical compounds, the sensory profile and physical appearances of four kinds of Gayo coffee which are Arabica regular, wild palm civet, cultivated palm civet and natural. The aims of this investigation are to identify and to map Gayo coffee based on specialty coffee SCAA standard. Later on the results could be used as bench marking tools to explore and to repair the unpleasant taste of coffee profile.

MATERIALS AND METHODS

Materials: These four kinds of Arabica coffee was obtained as green bean from Gayo Highland, Centre of Aceh Indonesia. Wild palm civet coffee (Kopi Luwak) was obtained from coffee producers located nearby forest at Bintang village. Cultivated palm civet coffee and Arabica regular collected from one coffee producer at AtuLintang village, whereas natural coffee gathered from KuteniReje village. Each kind of coffee, respectively required 3 kg. Chemical used were ethanol, alcohol 96%, ethanol, chloride acid, NaOH, sodium carbonate (Na_2CO_3), kalium sulfic and sulfic acid.

Methods: Arabica regular coffee (A), wild palm civet coffee (B), cultivated palm civet coffee (C) and natural coffee (D) are collected as green bean, then analyzed. The study was done explorative for these four kinds of samples with three replications, which total samples were 12 samples. Chemical compound analyses conducted in Food Analysis Laboratory-Department of Agricultural Product Technology Syiah Kuala University, where sensory properties and physical appearance was investigated by Gayo Cupper Team as Q-Grader in Takengon, Central Aceh, Indonesia.

Green bean processing: Coffee berries are harvested or collected from digestion of wild/cultivated Asian palm civet (*Paradoxurus hermaphroditus*). Harvested coffee berries produced regular Gayo Arabica coffee, whereas wild palm civet produced wild luwak coffee and vice versa. All Coffee berries except natural were cleaned, washed, fermented overnight then coffee pulp were removed. Washed bean was sun-dried up to moisture contents 12%, then the mucilage and husks were removed, cleaned then packaged. Natural is harvested coffee berries which are sun-dried without any kind of pre-treatments applied.

Chemical compound analysis: The coffee beans were evaluated for moisture, ash, fat and protein content (AOAC, 2000). The chemical analysis was done with three replications, hence twelve samples require for each chemical compound analyzed.

Cupping test: Cupping test is sensory property analysis where the descriptive method used. Cupping is roasted coffee evaluation that involves analyzing the aroma and flavor by coffee grader, who able to understand the differences of coffee from different origins, to determine sense of coffee accurately and to test coffee defects. The test ran down based on Specialty Coffee Association of America (SCAA, 2009) method. The green bean was roasted with 55 Agtron scale, then grounded up to 20 meshes. Grounded coffee was brewed in 93°C hot water with ratio 8.25 gram grounded coffee in 150 ml drinking water. Coffee was served and tested by 3 Q-grader Gayo Cupper Team, with scale 1 to 10. To be named as coffee

Specialty, sample obliges to reach at least 6 for one attribute and total score 80 from coffee ten sensory (attributes fragrance/aroma, flavor, acidity, body, uniformity, clean up, aftertaste, balance, sweetness and overall). Cupping test carried out with three replications, hence total samples were 12 samples for 10 attributes tested.

Physical appearance: Physical appearances of green bean measured include bean size, colors and total of quackery beans. Bean size measured by weighing 350 gram of coffee bean, sorted and graded onto four categories (>19 calculated the percentage of each category (SCAA, 2009). Bean colors were measured by SCAA standards for green bean color (SCAA, 2009). Quackery beans defined as defect where inches, <16 inches, >14 inches and <14 inches) unripe bean where the roasting is finished. Specialty coffee should not have any quackery beans (SCAA, 2009).

Partial least square (PLS): Cupping test data and results of chemical compounds analysis matched and analyzed with Smart PLS Ver. 3.2.3 (Ringle *et al*., 2015). Partial Least Square (Partial Least Square) Algorithm calculated the linear regression by projecting the chemical compounds as predicted variable and sensory properties as observable one in order to find fundamental relations between both data.

RESULTS

Chemical compounds: Lipid contents of four coffee samples varied between 1.19-1.21% where the highest belonged to wild palm covet coffee which also had highest score in cupping test. The moisture of coffee sample varied in range between 5.76-12.55%, which all of samples respectively met the requirements of SCAA standards (2009) and (SNI 2907-2008) where the maximum moisture content is 12.5%. The lowest moisture had by natural (5.76%) with dried surface and pale yellow color, which easily distinguished from others. Moreover crude protein contents varied between range of 8.86-9.83% where Arabica regular coffee as the highest, followed with wild palm civet, cultivated palm civet and natural.

Cupping test: Three out of four coffee samples have closed range of aroma and flavor respectively are Arabica regular, wild and cultivated palm civet coffee. However the remarks of coffee samples were noticeably different. Arabica regular tends to have nutty, *choco* and herby aroma with citrus flavor. Wild palm civet coffee was perceived to have *choco* and floral aroma with buttery, earthy flavor, but cultivated palm civet tends to have oily flavor. Natural coffee has lower aroma score since the green bean processing technique was different, where the remarks described the aroma as sweet tropical fruity, woody, rubbery and gummy. Coffee aroma generally represents the processing techniques behind. Natural which produces by dry methods, tends to have hard aroma such as earthy, woody and rubbery (Clarke and Macrae, 1985) than semi-washed or pulped natural like. Furthermore this four coffee samples reported to have similar score for sweetness, acidity and body, where wild palm civet coffee mentioned as coffee with highest score of balance, overall, clean cups and uniformity attributes.

Physical appearance: Table 2 mentioned that Arabica regular and cultivated palm civet coffee have range bean size 16 up to 19 inches with yellow green and greenish color and 1 quackery beans, whereas digested coffee from wild palm civet seems to be uniform in size less than 16 inches. Digested bio processing coffee either by wild or cultivated palm civet tends to have greenish color, whereas natural has pale yellow.

Partial least square: Figure 2 showed relationship between chemical compounds namely lipid, moisture and protein towards sensory profile, respectively acidity, aftertaste, aroma, balance, flavor and overall. Lipid tend to have positive regression with all five attributes except balance, whereas moisture seems to have negative regression with acidity, balance and flavor. Moreover protein tend to have positive regression for aftertaste, aroma and overall. Positive regression assumes the chemical compounds have positive relation with sensory attributes and vice versa.

DISCUSSION

Chemical compounds: Hayati *et al*. (2012) mentioned that lipid contents of green bean is in range of 2-6% and significantly has impact on flavor of brewed coffee. Lipid fraction of coffee consists of triglycerides, ester-alcohols, sterols and tocopherols (Kaufmann and Gupta, 1964; Kaufmann and Hamsagar, 1962). During roasting, lipid migrated to the bean surface causes the oily and glowing appearance (Savonitti, 2005) and then it carries

Table 1: Result of chemical compound analysis (%) (lipid, moisture, protein and mineral) of Arabica regular coffee, wild palm civet coffee, cultivated palm civet coffee and natural coffee

Arabica coffee sample	Lipid (%)	Moisture (%)	Crude protein (%)	Mineral (%)
Arabica regular	1.19±0.05	11.63±0.46	8.86±0.12	2.14±0.04
Wild palm civet	1.21±0.02	12.55±0.19	9.18±0.16	2.13±0.03
Cultivated palm civet	1.20±0.04	7.40±0.44	9.43±0.41	2.14±0.02
Natural	1.20±0.03	5.76 ±0.31	9.83±0.49	2.16±0.02

Table 2: Cupping test score

	Coffee sample			
Cupping test score	Arabica regular	Wild palm civet	Cultivated palm civet	Natural
Total score	83.75	85.25	79.50	79.50
Defects	0.00	0.00	4.00	2.00
final score	83.75	85.25	75.50	77.50

Table 2: Bean size, bean color and number of quackery bean of Arabica regular, wild palm civet coffee, cultivated palm civet coffee and natural per 350 gram sample

	Bean size (%)					
Arabica coffee sample	>19"	<16"	>14"	<14"	Bean color	Quackery bean
Arabica regular	49.10	46.90	4.00	0.00	Yellow green	1
Wild palm civet	17.00	71.50	10.90	0.60	Greenish	3
Cultivated palm civet	43.70	52.30	4.00	0.00	Greenish	2
Natural	19.50	52.50	16.80	1.20	Pale yellow	33

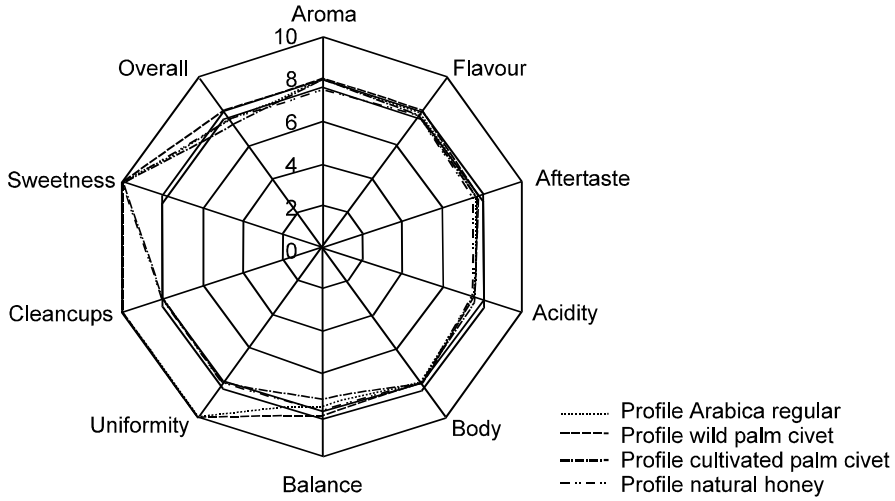

Fig. 1: Sensory profile of coffee Arabica regular, wild palm civet coffee, cultivated palm civet coffee and natural coffee obtained by Gayo Cupper Team based on SCAA Standard

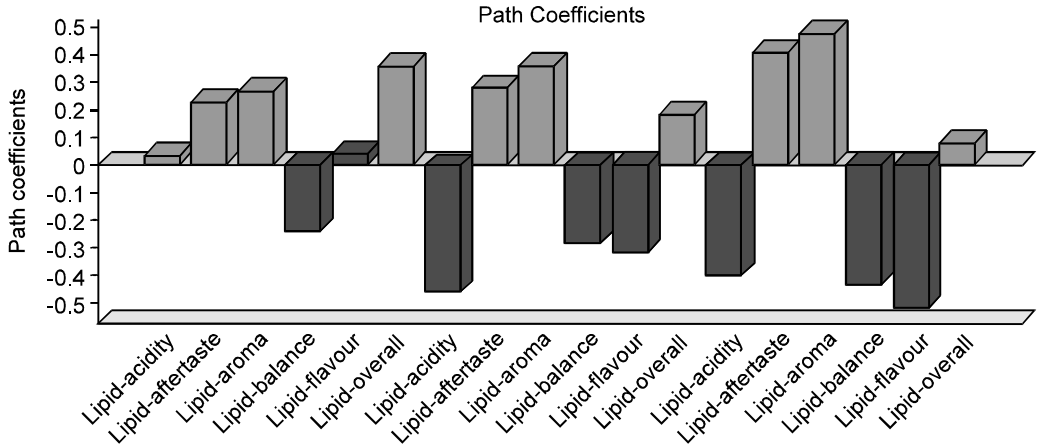

Fig. 2: Result of partial least square regression with chemical compounds (lipid, moisture and protein) towards sensory properties (acidity, aftertaste, aroma, balance and overall)

volatiles and fat soluble vitamins as well as contributes to body attributes in cupping test (Oestreich-Janzen, 2010).

On the other hand, protein and amino acids in green bean reported to have important contribution of flavor development through Maillard reactions during roasting (Liu and Kitts, 2011). However since this research did not identify the amino acids contents, there are any information given for that. Moreover, large difference of moisture was caused by different treatment in green bean processing. As natural is new developing method of green bean processing in Central Aceh, the quality was inconsistent. "Natural" was adopted similar-alike natural method for espresso coffee in Brazil, but without any kind of washing and sorting treatment involved.

Cupping test: Coffee sensory are the senses perceived by human which consider as complex combination of aroma, taste, texture and mouth feel (Taylor and Roozen, 1996) and trigeminal sensations (Cliff and Green, 1994). The aroma or fragrance and flavor fully considered as the primary point of coffee sensory profile. Aroma is retro nasal perception which is occurring when volatiles component flow from the mouth via back of throat reaching nasal cavity through the pharynx (Petracco, 2001) whereby the receptors on the olfactory epithelium sense the volatiles, respond and transmit its sensory information to the brain via olfactory bulb as odor recognition (Mombaerts, 2001a,b). But since in common knowledge consumers assume aroma as part of taste, which led to add other sensory attribute name flavor, defined as combination of smells of volatile compounds are inhaled through the nose (Petracco, 2001) and basic tastes are detected from tongue receptors (Rawson and Li, 2004). Arabica regular offers coffee with more mild aroma and intermediate body (Duarte *et al*., 2010).

Especially for digestive bio-processing such as coffee from wild or cultivated palm civet where the fermentation occurs inside the civet mammal intestine reported to have specific aroma and flavor profile (Jumhawan *et al*., 2013; Ongo *et al*., 2012).

Sweetness and acidity is classified as aroma and taste sensations, whereas balance, overall/body, clean cups and uniformity considers as trigeminal sensations, as sensory attributes perceived and influenced by food structure interaction with the lining of the mouth during consumption (Taylor and Roozen, 1996), while these sensations commonly are not detected via the olfactory system or taste receptor pathways (Cliff and Green, 1994.) Overall or body defines as the way coffee physically feels in the mouth, when lower score describes as light and silky and higher describes as heavy and gritty. Aftertaste represents a flavor that lingers after the coffee is swallowed, which also means as finish and clean cups defines how clean or lacking of the defect flavor from the cup tasted. Clean cups and uniformity were the key attributes which distinguished the Arabica regular and wild palm civet coffee from the others two coffee samples.

Physical appearance: Wild palm civet and Arabica regular have uniform bean size which also had normal range of moisture than others which also supported by Primadia (2009) that bean size and moisture contents are linked with quantities of cell components inside the coffee bean. For wild palm civet coffee, It also could be happened due to wild palm civet has consistent preferences toward certain bean size, i.e., less than 16 inches. Digested bio processing coffee either by wild or cultivated palm civet tend to have greenish color since the bean were fermented inside its intestine, whereas natural have pale yellow due to different processing techniques where it sun-dried without pulp removal, which cause high number of non-dried bean even after roasting (quackery bean).

Partial least square: At present study, lipid tends to have positive regression with acidity, aftertaste, aroma, flavor and overall. Lipid fraction of coffee some changes and some remains unchanged during roasting (Maier, 2005). Although lipid of coffee bean are not involved in Maillard reactions, they reveal an important influence on the flavor of beverages. Lipid solve hydrophobic flavor components (Ill and Viany, 1995). Minor degradation of lipid and interaction between intermediate products during roasting also contribute on coffee flavor. Protein tends to have positive regression for aftertaste, aroma and overall. Peptides and proteins are considered as aroma precursors (Ludwig *et al*., 1997). Amino acids content of green bean has an important contribution to flavor development during roasting through Maillard reaction and Strecker degradation (Buffo and Cardelly-Freira, 2004; Flament, 2001; Liu and Kitts, 2011). Maillard reactions have been identified to be the major pathway in the formation of volatile compounds in coffee roasting. In the Maillard reaction, reducing sugars such as glucose or fructose react with free amino acids to form N-substituted glycosylamine adducts, which are then rearranged to aminoketones and aminoaldoses. A complex reaction cascade leads to numerous volatile compounds and complex melanoidins (Shibamoto, 1991).

Conclusions: Taking everything into consideration from four samples Gayo coffee tested only fermented coffee from wild palm civet and regular Arabica coffee met SCAA standard and could gained label of specialty coffee. Gaining label as coffee specialty means having higher standard from average or good coffee. Coffee specialty must reach minimum score total 80, since Arabica regular and wild palm civet coffee respectively had total score 83.75 and 85.25 both of these coffee met the requirements of sensory profile of coffee specialty. Chemical compounds certainly derive sensory perceived in cupping test however further research should be done to analyze other component such as volatile compounds in these four samples.

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