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Physicochemical and sensory characteristics of *luwak* coffee from Bener Meriah, Aceh- Indonesia

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Abstract. *Luwak* coffee is product diversification of coffee which has the highest selling prices and is considered as the world's rarest bean. This condition comes out as an impact of its unique production method. Kopi *luwak* is made from coffee beans that are eaten and digested by Asian civet (*Paradoxorus hermaphroditus*) or *luwak* (Indonesian) and then excreted by the civet. The beans are collected from the excretion, washed, sun-dried and skin removing and roasting. This study aims to explore the physicochemical specifically colour and caffeine conrents and sensory characteristics of *luwak* coffee obtained from certain location in Bener Meraih districts, Gayo Highland, Aceh – Indonesia. The study points out that *luwak* coffee processing tend to produce green bean with pale yellow colour, and caffeine contents (1.08-1.24%) which ensure that Asian civet has eaten Arabica varieties. The caffeine contents for both green and roasted bean are slightly changes. Furthermore the data correlation shows that caffeine has strong uphill relationship with fragrance, flavour, overall and final score of sensory attributes, whilst the correlation is vice versa for perceived body and balance of *luwak* coffee samples.

1. Introduction

As a world's popular beverage, coffee is still attracting many researchers to explore its quality started from the farm to the cup. The investigation towards its quality is still counted as an ongoing research, since the quality of coffee as brewed drink is considered as the manifestation of all input process started from the bean to the cup [1], which includes such as elevation level and altitude of land, kinds of shading trees, the harvesting method, the green bean processing, the drying and roasting method, until to the brewing techniques [2], [3]. On the other hand, the indigenous knowledge from coffee producing countries also tends to interfere the quality [4] of coffee since these producing countries have several unique ways to produce a specialty and premium quality coffee, such as *luwak* coffee [5], [6].

Luwak coffee is one of the most preferable coffee in the world. This coffee is fermented inside *luwak* or Asian civet (*Paradoxorus hermaphroditus*) intestine. The process started from the coffee

cherries consumption by Asian civet or *luwak* then excreted in the full form but without the cherries skin. The feses the collected, washed, dried and then continued to process generally [7], [8], [9]. As it has unique process and limited production, which distinguishes *luwak* coffee as exclusive coffee products with the most expensive price. This reputation caused the increasing demands for *luwak* coffee, which negatively leads to food fraud, by claiming its authenticity. Unfortunately, the quick and affordable method to test its originality is still unavailable. On the other hand, halal controversy and safety issues are also still influence consumer preferences and reaches problem on trading of *luwak* coffee [10], [9].

Farming *luwak* coffee ever acknowledged as solution for its limited productivity, but then this methods was blocked up since it against the animal rights [10]. Therefore production *luwak* coffee which excluding the Asian civet or *luwak* itself counts as a promising way-out for these problems mentioned above. The artificial fermentation method could be done by imitating the fermentation inside Asian civet/*luwak'*s intestine, which is considered to have major influence in coffee fermentation. However up to this now, the biochemical reaction during the fermentation inside Asian civet/*luwak* intestine is still unknown. Not only that, the quality of *luwak* coffee is also not scientifically reported. This is a cause of limited publication related this kind of coffee production, for both wild and previous farming method, since it has low productivity and only produced by specific location in Asia, such as in Gayo Highland, Aceh-Indonesia

Gayo Highland is the largest Arabica coffee plantation in Indonesia, which has specific green bean processing methods such as *giling basah, natural* and *luwak* coffee [11]. One of location in Gayo Highland which produced *luwak* coffee is Bener meriah districts. This districts lies on the central of Aceh Province, as a guardian of Lueser ecosystem area [12]. Bener Meriah has area 1.919,69 km^2, located 4^o 33 50 - 4^o 54 50 North Latitude and 96^o 40 75 – 97^o 17 50 East Longitude, where the elevation level varied from 100 up to 2500 above sea level. This location makes Bener Meriah as suitable location for Arabica coffee plantation [13], [14], [15]. Based on the explanations above, this study aims to explore the *luwak* coffee quality originated from Bener Meriah, especially focus on its physical quality (bean size, bean colour), chemical quality (caffeine contents for both green bean and roasted bean) and cupping quality as specialty coffee based on Specialty Coffee Association of America (SCAA) standard [16]. This finding is aimed to be used as quality parameter to produce artificial *luwak* coffee.

2. Methods

2.1. Sampling and sample preparation

As an explorative study, the work started by obtaining sample from three location in Bener Meriah districts (4^o 33 50 - 4^o 54 50 North Latitude and 96^o 40 75 – 97^o 17 50 East Longitude) which identified as *Wih Pongas* (sample A), *Blang Panas* (sample B) and *Kenawat Redelong* (sample C). The obtained feses sample then were cleaned, manually dried up to moisture 12%, dried hulling manually to remove the silver skin. The resulted green bean is stored in vacuum container in humid room temperature prior to analyses.

2.2. Physicochemical analyses

The physical analysis were including colour, moisture contents (%) and size of green bean. Colour and size of green bean procedures were followed based on SCAA standard (2014), whereas moisture contents based on AOAC (2005). Chemical analysis in this research refered to caffeine contents of roasted bean with High Performance Liquid Chromatography (HPLC) with column used is Sunfire c 18 5m (C 18 5 m (150 x4,6 mm), a combination of 0.1% acetic acids and methanol with ratio 80:20 as active phase at 1 ml per minutes with an injection volume of 10 ml. Furthermore, especially for caffeine and chlorogenic acids, UV detector was arranged at 278 nm. The tests were done in two repetitions.

2.3. Data correlation

The relationship between caffeine contents and the sensory quality of *luwak* coffee roasted bean had been examined. The sensory data was reported by [17], as can be seen in table 1 and table 2. The data tabulation and correlation was done using Microsoft Excel 2010.

Table 1. Score of measured sensory attributes of *luwak* coffee.

Sample (location)	Fragrance	Flavour	Aftertaste	Acidity	Body	Balance	Overall
A (*Wih Panas)*	8.00	7.80	7.50	7.50	8.00	7.80	7.80
B (*Blang Panas)*	8.00	8.00	7.80	7.50	7.80	7.50	8.00
C (*Kenawat Redelong)*	7.80	7.50	7.80	7.50	8.00	8.00	7.80

Source: Muzaifa et al., (2017)
9.00-9.75 = Outstanding; 8.00-8,75= Excellent; 7.00-7,75= Very Good ; 6.00-6.75= Good

Table 2. Aroma remarks and final score of *luwak* coffee.

Sample (location)	Aroma remarks noted by Q-grader	Final score
A (*Wih Panas)*	Nutty, wattery, fishy, chocolaty, citrussy, slighty woody, sweet	84.00
B (*Blang Panas)*	Nutty, chocolaty, wattery, fishy, biscuity, gardenpeas, herby	84.75
C (*Kenawat Redelong)*	Nutty, aged, chocolaty, toasty, herby, fishy, slight earthy	83.75

Source: Muzaifa et al., (2017)
90-100: Outstanding Specialty Coffee; 85.89-89.99= Excellent Specialty Coffee; 80.00-84.99= Very Good Specialty Coffee; <80.00 = Below Specialty Coffee.

3. Results and discussion

3.1. Physicochemical analysis

The colour of green bean was shown in figure 1. The green bean processing technique is assumed to have major influence for the minor differences of obtained sample.

Figure 1. The sample's colour of green bean, A (Wih Panas), B (Blang Panas) and C (Kenawat Redelong).

In general, green bean has normal green colour which is caused by chlorophyll compound of bean, but in further stage of processing this normal colour will slightly changes. Arabica from Gayo Highlands commonly was classified as greenish green bean, since it was produced with semi-wash processing [18]. On the other hand Ethiopian Arabica, which was normally produced with full wash processing tend to classify as blue green bean [18]. But for this *luwak* coffee, the colour is distinguished as pale yellow and yellow green as can be shown in Table 3. This variation seems to be an impact of fermentation media since coffee bean has high ability to absorb the surrounding environment. Then colour variation of green bean is an indication of the oxidation and biochemical transformation during the green bean processing which is naturally changed the chemical composition of green bean [19], [20]. [21].

From Table 3 it can be seen that the moisture contents is varied from 11.0% to 14-3%. The obtained moisture contents from Sample A and B met both of Indonesian and SCAA standard, which the maximum value is 12.5%. The moisture contents represents the good post-harvest practices, higher and lower moisture contents in green bean led to poor drying process and inadequate control [23]. In detail higher moisture contents would lead to microbial and mould growth as can be seen in Sample C, which has higher moisture contents and detected to have an off flavour aged in fragrance remarks [24], [17]. The bean size and moisture contents are linked with quantities of cell components inside the bean [25]. Table 3 also shows the bean size based on screening. For sample A and B, the amount of bean which has size bigger than is nearly 94%. *Wih Panas* and *Blang Panas* are closely located, whilst 68% sample C has size bigger than 68.00%. Asian civet ha primitive instinct to choose the best cherries, as also pointed by [18] that Asian civet has consistent preferences towards certain bean size, i.e. varied from 16-19 inches.

Table 3. Green bean colour and caffeine contents (%) of *luwak* coffee sample.

Sample **(**Location)	Green Bean					Caffeine of Roasted Bean (%)
	Colour	Moisture	Bean Size (Screen)			
			>19”	>16”	>14”	
A (*Wih Panas)*	Pale Yellow	11.0%	94.0%	6.0%	0%	1.16±0.064
B (*Blang Panas)*	Yellow Green	11.0%	94.0%	6.0%	0%	1.18±0.007
C (*Kenawat Redelong)*	Pale Yellow	14.3%	25.0%	68.0%	6.0%	1.08±0.014

From table 3 it can be clearly seen that the caffeine after roasting is in the range 1.08-1.18% with average 1.14%. Caffeine is main alkaloid found in coffee, which is reported as responsible component of coffee which gives a psychostimulant effect [1], [23]. Table 3 also presents a slightly decrease of caffeine compounds after roasting as heat treatment process. As coffee *luwak* is gathered from Asian civet excretion, the varieties are unknown. But from the caffeine contents, it can be concluded that the Asian civet or *luwak* eaten Arabica varieties. Gayo Highland, including Bener Meriah districts is dominantly planted with Arabica coffee. Some researchers reported that caffeine content in green bean dry basis measurement is 0.9-1.2% whilst the roasted has caffeine between 1.1-1.3% [26], [27]. However we should take the difference cultivation methods, climate condition, cultivars and soil condition into account since coffee is very sensitive towards the mentioned conditions. Several researchers have been reported the caffeine contents of Gayo Arabica coffee, which in the range of 0.8-1.1% [28], [15]. Arabica has lower caffeine (0.9-1.2%) than Robusta which can reach 2% or more [29], [30], [31].

3.2. Correlation of caffeine and contents and sensory attributes

Table 4. Correlation data of caffeine and sensory attributes.

Parameters	Fragrance	Flavor	Aftertaste	Body	Balance	Overall	Final
Caffeine Green Bean	+0.92	+1.00	-0.11	-0.80	-0.97	+0.80	+0.92
Caffeine Roasted Bean	+0.98	+0.98	-0.33	-0.65	-0.90	+0.65	+0.82

As beverage drink, the cupping quality is considered as main requirement of coffee trading. The cupping quality is measured based on brewing test named as cupping test, as a systematic system to evaluate the coffee flavour, aroma characteristics and as well as the defects quality. This cupping test could examined the quality consistency of coffee which then associated with economic value [32]. Based on table 2 as reported by [17], it can be shown that Sample B has highest score for each measured attributes, which counts to gain 84.75 point as final score and considered as sample with better quality sensory.

Table 4 shows the relationship between caffeine and sensory attributes of three *luwak* coffee samples. The positive (+) symbol illustrates the positive linear relationship between the parameters, whereas negative (-) symbol emphasizes the vice versa, negative linear relationship. As can be seen in Table 4, both of caffeine in green and roasted bean is strongly correlated (close to +1.00) towards fragrance and flavour of brewed drink. Flavour covers the perceived sensation of aroma noticed by retro nasal systems along with the perceived taste by the olfactory system meanwhile fragrance [1]. , where caffeine is thought to influence a bitter flavour of coffee[26]. Moreover, caffeine as non-volatole compounds, is one of bioactive compounds which has important contribution to the flavour development of coffee during and after the roasting process. Even caffeine is known based on its characteristics [23]. This compounds is only responsible for up to 10% of bitterness sensation in brewed coffee, which commonly perceived as aftertaste attributes [33]. Aftertaste define as the perceived mouthfeel after drinking the beverage, acidity refers to the sweetness and fruitful crispiness of the liquor [1]. Table 4 also emphasizes a weak linear negative relationship between caffeine and aftertaste. Moreover, body and balance showed strong downhill relationship which indicates that when the caffeine contents increase then the perceived body or balance will decrease or vice versa. Even caffeine was assumed to have major influence in the perceived strong body [26], but later [34] stated out that water soluble polysaccharides which appear after roasting, has major contribution towards brewed drink viscosity as known as ‘body” in the mouth. Therefore there is an assumption that higher caffeine will lower the perceived body and perfect synergy of mixed attributes in coffee brewed.

4. Conclusions

Taking everything into consideration, it can be concluded that quality of *luwak* coffee depends on the animal instinct and preferences of Asian civet towards coffee cherries as its diet intake, since the processing could be started by excretion collection. Moreover *luwak* coffee tends to have pale yellow colour and caffeine contents is varied from 1.08% to 1.24% with slightly differences for both green and roasted bean. The cupping quality shows that all samples fulfilled the required standard for coffee specialty with final score varied from 83.75-84.75 points. The coffee has noted to have specific characteristics of Gayo coffee (nutty) and fishy aroma as drawback of fermentation inside *luwak* intestine. Last, the correlation between caffeine and sensory attributes points out strong linear uphill relationship between correlation and fragrance, flavour, overall and final score, whereas for the balance and body surprisingly shows the negative correlation towards caffeine.

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