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A Study of Compound Changes in Coffee Beans by Different Roasting Condition

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ABSTRACT: This study aimed to investigate changes in the diverse compound in coffee beans under different roasting conditions. Four different kinds of chemical characteristics (phenolic contents, flavonoid contents, chlorogenic acid, and caffeine) were analyzed. According to the temperature of coffee roasting, this study categorized green bean, extract A (191℃), B (202℃), C (220℃), and D (233℃). As a result, total phenol compound showed low level of total phenol compound at lower temperatures. Extract A showed significantly higher level of total flavonoid (111.33±10.14), green bean showed 83.67±2.43, Extract B 46.11± 2.38, C and D showed 31.44±0.12, 19.22±0.46 respectively. Green bean showed higher level of chlorogenic acid (64.47±0.51), Extract A (39.66±0.47), extract B (12.45±0.99), C, D (3.59±0.31, 0.63±0.12) respectively. This study also noted that there are significant different in terms of caffeine content. Extract A has higher level of caffeine content (38.45±1.70) significantly, green bean (27.14±2.27), extract B (18.95±0.64), extract C (17.89±0.96). As a conclusion, we revealed that roasting conditions play an important role in the composition of coffee compounds.

Keywords: coffee green beans, coffee roasting, phenolic contents, flavonoid contents, chlorogenic acid, and caffeine

INTRODUCTION

The quality of our modern life has been increasing due to rapid economic growth and expanded leisure time. Also, lifestyle changes have also had an effect on the trend increasing total amount of coffee import[1]. Coffee is introduced in the country, estimated at around 1890[2]. The etymological origin of the legendary Kappa (kaffaa) of Ethiopia for the word (coffee) coffee[3]. Coffee is one of the most popular beverages in the world, containing its unique flavor[4]. As one of the world's most traded products-second in value only to oil-the coffee industry employs millions of people around the world through its growing, processing and trading[5]. But while the coffee trade is vital to the politics, survival and economies of many developing nations, the industry's pricing and futures are decided in conference rooms and on stock exchange floors in some of the world's wealthiest cities[4,5]. Not everywhere is suitable for coffee to grow, the place where coffee can be planted is tropical and subtropical zone. The natural condition the coffee need is calm wind, warm cool, shade and moist. So, the zone nearby the equator between 25°S and 25°N is the best place for coffee growth, called coffee belt or coffee zone. Coffee is originated in Africa, the coffee arabica is native to the tropical high altitude area between 900 meter and 1,800 meter of Ethiopia, the average annual temperature is 19 ℃[5]. The coffee robusta is native to the tropical rain forest area at an altitude below 900 meter, the average annual temperature of there is 21～26℃. These

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country of origins are shade or half shade rain forest and river valley area decide the coffee growth need calm wind, shade, warm cool and moist condition[4].

The Swedish botanist Carolus Linnaeus (1707～1778) was the first to described the coffee genus in his publication "Species Plantarum", which he published in 1753. Carolus Linnaeus classified the coffee tree as belonging to the botanical family Rubiaceae (more commonly called the Madder family) which has some 500 genera and over 6,000 species[5]. Coffee is a mixture of chemical compounds which are either occurring or formed during the roasting process. Green coffee beans contain several phenolic compounds[6]. The chlorogenic acids are esters formed between quinic acid and cinnamic acids such as caffeic, ferulic and pcoumaric acid[7,8]. During roasting, coffee beans are heated at 200～240℃ depending on the degree of roasting (light, medium, and dark roasted coffee)[9]. The beans change their color with the temperature increase and their density decreases due to the volume increase of the beans. The chemical composition of the beans is modified and hundreds of chemicals which give coffee's aroma and taste are formed. Roasting is responsible for a decrease in the content of protein, aminoacids, chlorogenic acid and for the increase in volatile compounds and melanoidins formation[6].

Among the many processes that coffee undergoes, from the seed to the cup, roasting is undoubtedly crucial[4]. A green coffee bean contains all necessary ingredients for the development of its flavor. During roasting, coffee beans are heated at 200～240℃ depending on the degree of roasting (light, medium, and dark roasted coffee). The beans change their color with the temperature increase and their density decreases due to the volume increase of the beans. The chemical composition of the beans is modified and hundreds of chemicals which give coffee's aroma and taste are formed. Roasting is responsible for a decrease in the content of protein, amino acids, chlorogenic acid and for the increase in volatile compounds and melanoidins formation[10]. Chlorogenic acids are degraded proportional with theroasting degree; the loss is higher in dark roasted coffee. Degradation of chlorogenic acids leads to quinic acid and to others phenols found in coffee's aroma[11,12]. However scientific approach concerning the contents in coffee beans cannot be found, only few papers about composition in coffee being available[13]. Therefore, this study aimed to investigate changes in the diverse compound in coffee beans under different roasting conditions.

MATERIALS

Guatemala Antigua SHB (Strictly Hard Bean) s were roasted in a at 191℃, 202℃, 220℃ and 233℃. to give light, medium and dark coffee samples. The water content of sample were average 11.1% using by moisture meter and 500 g beans were used for each samples. To determine related compounds in the ordinary coffee liquid that is normally consumed, the following methods were employed.

Roasting machine was a gas type, semi direct type, semi hot air type (model THCR-01, Taehwan Automatic Company Co., Ltd.). At input roasting temperature of 200℃, coffee beans were roasted. Exhaust temperature was 191℃ (Extract A), 202℃ (Extract B), 220℃ (Extract C), and 233℃ (Extract D), The beans weigh 450 g (Extract A), 430 g (Extract B), 415 g (Extract C), and 390 g (Extract D). First crack was same to 190℃. Agtron/scaa 85～95 (Extract A), 65～75 (Extract B), 55～45 (Extract C), 35～25 (Extract D). were recorded (Table 1).

The research during July 22nd to August 11st sent the samples twice to Korea Basic Science Institute for analysis. Among the data of effective component content in the sample, total phenolic content, total flavonoid content, Chlorogenic acid, Caffein were analysed using UV/Visable Spectrophotometer (Ultrospec 5300 pro, GE healthcare), HPLC (Agilent Technologies 1290 Infinity), ands [TCC-G1316C, DAD-G-4212A, Bin Pump-G4220A, Sampler-G4226A]. To see total phenolic contents, gallic acid (0, 40, 80, 120, 160, 200 μg/mL) were used as a standard. For total flavonoid contents, catechin (0, 1, 5, 10, 20, 50, 100 μg/mL) were used as a standard. Using HPLC, Chlorogenic acid and caffein were analysed with Zorbax SB-C18 (2.1×150 mm, 1.8 μ, Agilent) at 30℃ Column Temperature.

Using SPSS 20.0 program. ANOVA was used to see the mean differences among for characteristics such as total phenolic content, total flavonoid content, Chlorogenic acid, and Caffein. As a post-hoc test,

Table 1. Characteristics of materials

	Exhaust temperature (℃)	Beans weight (g)	First crack (℃)	Agtron/scaa (NO)
Green bean		500		
Extract A	191	450	190	85~95
Extract B	202	430	190	65~75
Extract C	220	415	190	55~45
Extract D	233	390	190	35~25

this study employed Duncan's multiple range test (p <0.05).

RESULTS & DISCUSSION

According to roasting duration time, extract A showed significantly higher level of total phenolic contents (132.40±7.48) followed by green bean (86.27 ±0.32), Extract B (60.47±2.51), Extract C (48.67±1.31), Extract D (33.87±0.11), respectively (Table 2). Bar graph (Figure 1) of the total phenolic contents shows that beans roasting at low level of temperature have higher level of total phenolic contents significantly (p< 0.001). Previous study reported that phenolic hydroxyl (OH) can combine with protein and activate biological activity such as antioxidation, anticancer, and antibacterial function[14]. Farah A, Donangelo CM (2006) also reported that total phenolic contents were moderately increased and decreased again[15].

Table 3 showed that Total flavonoid content of

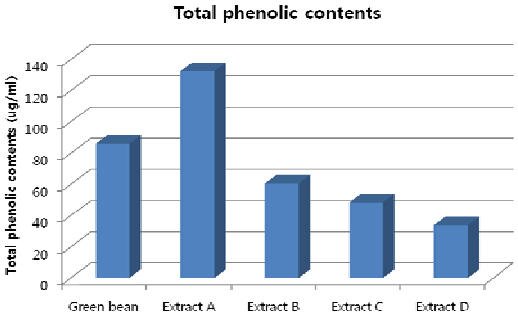

Figure 1. Total phenolic content of roasted coffee by different roasting condition.

roasted coffee by different roasting condition. Extract A (111.33±10.14) showed highest level of total flavonoid contents (μg/mL), followed by green bean (83.67±2.43), Extract B (46.11±2.38), Extract C (31.44 ±0.12), Extract D (19.22±0.46), respectively (Table 3). Bar graph (Figure 2) displayed a similar shape with the result of total flavonoid content. This result show-

Table 2. Total phenolic content of roasted coffee by different roasting condition Mean±S.D.

Beans	Total phenolic contents (μg/mL)	F-value
Green bean	86.27±0.32^{b}	
Extract A	132.40±7.48^{a}	
Extract B	60.47±2.51^{c}	350.107***
Extract C	48.67±1.31^{d}	
Extract D	33.87±0.11^{e}	

1) *** p<0.001.
2) $^{a\sim e}$ Means in a column are significantly different at the p<0.05 level by Duncan's multiple range.
3) Extract A:, Extract B:, Extract C:, Extract D:.

Table 3. Total phenolic content of roasted coffee by different roasting condition Mean±S.D.

Beans	Total flavonoid contents (μg/mL)	F-value
Green bean	83.67± 2.43^{b}	
Extract A	111.33±10.14^{a}	
Extract B	46.11± 2.38^{c}	191.612***
Extract C	31.44± 0.12^{d}	
Extract D	19.22± 0.46^{e}	

1) *** p<0.001.
2) $^{a\sim e}$ Means in a column are significantly different at the p<0.05 level by Duncan's multiple range.
3) Extract A:, Extract B:, Extract C:, Extract D:.

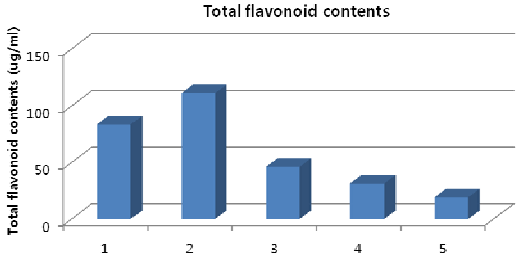

Figure 2. Total flavonoid content of roasted coffee by different roasting condition.

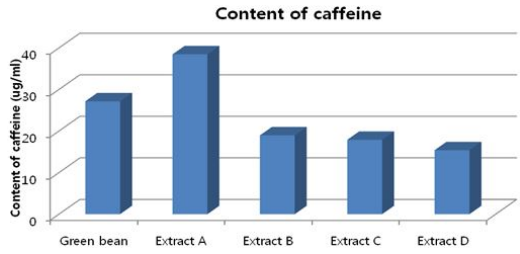

Figure 3. Caffeine content of roasted coffee by different roasting condition.

ed accordance of previous research[16].

According to caffeine content of roasted coffee, Extract A showed significantly higher level of content of caffeine (38.45±1.70) followed by green bean (27.14±2.27), Extract B (18.95±0.64), Extract C (17.89 ±0.96), Extract D (15.39±0.57), respectively (Table 4). Bar graph (Figure 3) of the caffeine contents shows that beans roasting at low level of temperature have higher level of caffeine contents significantly ($p<$ 0.001). The literature suggests that the following effects on behavior of adult humans may occur when individuals consume moderate amounts of caffeine. Caffeine increases alertness and reduces fatigue[17]. Caffeine improves performance on vigilance tasks and simple tasks that require sustained response. Effects on more complex tasks are difficult to assess and probably involve interactions between the caffeine and other variables which increase alertness (e.g. personality and time of day).

Table 4. Caffeine content of roasted coffee by different roasting condition Mean±S.D.

Beans	Content of caffeine (μg/mL)	*F*-value
Green bean	27.14±2.27^{b}	
Extract A	38.45±1.70^{a}	
Extract B	18.95±0.64^{c}	137.295***
Extract C	17.89±0.96^{c}	
Extract D	15.39±0.57^{d}	

1) *** $p<0.001$.
2) $^{a\sim e}$ Means in a column are significantly different at the $p<0.05$ level by Duncan's multiple range
3) Extract A:, Extract B:, Extract C:, Extract D:.

Chlorogenic acid content of different roasting level of coffee beansis presented in Table 5 and Figure 4. Chlorogenic acid content of brews significantly decreased with the increase of roasting degree, at all roasting temperatures. Chlorogenic acids (CGA) are cinnamic acid derivatives with biological effects mostly related to their antioxidant and antiinflammatory activities. Chlorogenic acid is a phytochemical found in coffee and coffee beans. It has been touted as being able to reduce blood sugar levels and potentially exert an anti-diabetic effect. It has also been implicated in weight loss and exerting an anti-obesity effect, but that is insofar correlation and not necessarily due to chlorogenic acid. It can be beneficial to supplement, although doses found in food sources are enough for a long-term preventative (anti-diabetic) measure[7,9].

SUMMARY AND CONCLUSIONS

According to roasting duration time, extract A showed significantly higher level of total phenolic contents (132.40±7.48) followed by green bean (86.27 ±0.32), Extract B (60.47±2.51), Extract C (48.67±1.31), Extract D (33.87±0.11), respectively. Bar graph of the total phenolic contents shows that beans roasting at low level of temperature have higher level of total phenolic contents significantly ($p<0.001$). Total flavonoid content of roasted coffee by different roasting condition. Extract A (111.33±10.14) showed highest level of total flavonoid contents (μg/mL), followed by green bean (83.67±2.43), Extract B (46.11±2.38), Extract C (31.44±0.12), Extract D (19.22±0.46), respectively.

The results displayed a similar with the result of total flavonoid content. According to caffeine con-

tent of roasted coffee, Extract A showed significantly higher level of content of caffeine (38.45±1.70) followed by green bean (27.14±2.27), Extract B (18.95±0.64), Extract C (17.89±0.96), Extract D (15.39±0.57), respectively (Table 4). Bar graph (Figure 3) of the caffeine contents shows that beans roasting at low level of temperature have higher level of caffeine contents significantly (p<0.001). The literature suggests that the following effects on behavior of adult humans may occur when individuals consume moderate amounts of caffeine. Caffeine increases alertness and reduces fatigue. Caffeine improves performance on vigilance tasks and simple tasks that require sustained response. Effects on more complex tasks are difficult to assess and probably involve interactions between the caffeine and other variables which increase alertness (e.g. personality and time of day).

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Table 5. Total phenolic content of roasted coffee by different roasting condition Mean±S.D.

Beans	Content of chlorogenic acid (μg/mL)	*F*-value
Green bean	64.47±0.51[a]	
Extract A	39.66±0.47[b]	
Extract B	12.45±0.99[c]	7097.865[***]
Extract C	3.59±0.31[d]	
Extract D	0.63±0.12[e]	

1) [***] p<0.001.
2) [a~e] Means in a column are significantly different at the p<0.05 level by Duncan's multiple range.
3) Extract A:, Extract B:, Extract C:, Extract D:.

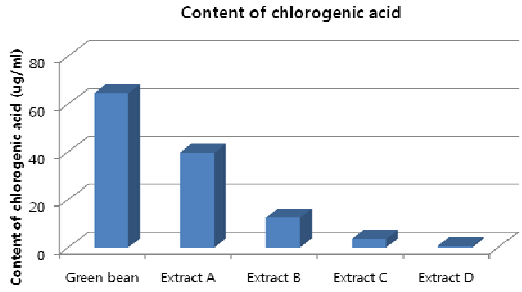

Figure 4. Chlorogenic acid content of roasted coffee by different roasting condition.

In conclusion, phenol compound content showed significantly high level in Extract A (132.40±7.48), total flavonoid content also showed highest level in Extract A (111.33±10.14). For caffeine content, extract A showed highest level (38.45±1.70) and green bean has significant higher level of chlorogenic acid (64.47 ±0.51).

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REFERENCES

[1] Lee SH (2015). The impact of coffee barista jab stress on job satisfaction and organizational loyalty. *Korea J Culinary Res* 21(6):91-102.
[2] Jin YH (1999). A study on the present condition of the coffee and vision of 21C in Korea. *Korea J Culinary Res* 5(2):5-24.
[3] Min KH(2009). A study on the education for employees in coffee restaurants from employers` viewpoint. *Korea J Culinary Res* 15(3):271-283.
[4] Seo JW (2013). *Coffee Bible*. Daewangsa Publishing Co. Kyunggi.
[5] Lee JC (2013). *Introduction of New Food & Beverage*. Baesan Publishing Co. Kyunggi.
[6] Kim KJ, Park SK (2006). Changes in major chemical constuents of green coffee beans during the roasting. *Korean J Food Culture* 38(2):153-158.
[7] Clarke RJ, Macrae R (1887). *Coffee Vol. 1: Chemi-*

stry. Elsevier Applied Science Publishers Ltd., p. 223-262.

[8] Halliwell B, Aeschbach R, Loliger J, Aruoma OI (1995). The characterization of antioxidants. *Food Chem Toxicol* 33:601-617.

[9] Feldman JR, Ryder WS, Kung JT (1969). Importance of non-volatile compounds to the flavor of coffee. *J Agric Food Chem* 17:733-739.

[10] Macdonald IA, Macrae R (1985). The determination of amino acids in coffee products. Proc ASIC, Berlin, Germany. p. 333-340.

[11] Newton JM (1979). Spectrophotometric deterimnation of caffeine in coffee products. *J Assoc Anal Chem* 62:705-708.

[12] Moon JW, Cho JS (1999). Changes in flavor characteristics and shelf-life of roasted coffee in different packaging conditions during storage. *Korean J Food Sci and Tech* 31(2):441-447.

[13] Imai J, Ide N, Nagae S, Moriguchi T, Matsuura H, Itakura Y (1994). Antioxidant and radical scavenging effects of aged garlic extract and its constituents. *Plant Med* 60:417-420.

[14] Rice-Evans CA, Miller NJ, Paganga G (1997). Antioxidant properties of phenolic compounds. *Trends Plant Sci* 2:152-159.

[15] Farah A, Donangelo CM (2006). Phenolic compound in coffee. *Braz J Plant Physiol* 18:23-26.

[16] Rice-Evans CA, Miller NJ, Paganga G (1996), Structure antioxident activity relationship of flavonoids and phenolic acids. *Free Radical Biol Med* 20:933-956.

[17] Chen JH, Ho CT (1997). Antioxidant activities of caffeic acid and its related hydroxycinnamic acid compounds. *J Agric Food Chem* 45:2374-2378.

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