EPR Study of Coffee

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Six medium and dark roast coffees and its grounds and one non-roast coffee samples in solid state from the one of coffee shops in Ulaanbaatar city were studied by the EPR spectroscopy. Singlet, low intensity but broad (16-17 Gs) EPR spectrum was registered near the 3400 Gs magnetic field from the all samples. Free radical concentration was evaluated about 10^{16} spin which can be a measure of antioxidative property.

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I. INTRODUCTION

It is just very few years that in Ulaanbaatar city there were opening coffee shops and coffee cafes as a new business trend, but nowadays in every street has its own coffee drinking places which are busy and crowd with hours working.

So it is interesting for us what are we interested in drinking, how healthful is this coffee actually or the formulation would be correct if we learned to prepare the coffee in its right way, since coffee has its many years useful use by people in the world.

Looking in the researching of coffee in agricultural and food chemistry field it was recognizable that coffee could be as a source of antioxidant. The property of antioxidant in coffee components was studied in many ways such as using powerful oxidant for reactions with coffee components or roasting degree dependence and its condition and etc [1-3].

Antioxidant activity can be successfully studied by electron paramagnetic resonance (EPR) spectroscopy because in coffee as a soluble and a non-soluble it was found a carbon and oxygen centered free radical singlet EPR line [1-6].

Therefore, in the present work an EPR spectroscopy is applied to study coffees as a raw, a prepared (roasted under certain condition) and its grounds (as a coffee brew quality prepared under certain condition) taken from one of Ulaanbaatar coffee shops for the characterization.

II. EXPERIMENTALS, DISCUSSION AND RESULTS

Six medium and dark (it is also called a full city) roast coffees and its grounds and one non-roast coffee samples in solid state from one of the Ulaanbaatar coffee shops, but originally from Mexico, Indonesia, Colombia, Brazil, Honduras grown pure Arabica sort coffees were studied by EPR spectroscopy.

Arabica coffee is hand grown plant that milder by its flavor and taste than the wild sort of Robusta and prepared as hand pick-up from the coffee tree and machine-sorted seeds by their sizes. These seeds then are dried before use. Drying step of the coffee seeds is different in every country according to the continental and climate conditions.

In our case the imported coffee raw seeds were roasted before use. The roasting condition was the following: The seed was heated continuously by its all side in the temperature from the 30^0C up to 180^0C by constant increase of the temperature. When the temperature reaches 180^0C there is the first crack sound and it is ready the medium roast coffee. Further 210^0C there is the second crack sound and the dark roast coffee in which seed oil was emerged outside of the seed skin.

These roasted samples of coffee were then crushed in a coffee breaker to a size as small particle as of up to 0.2 mm or less and bigger size particle up to 0.7 mm or less, and later these both sizes separately were applied for the spectroscopic analysis.

Further, for the coffee brew spectroscopic analysis means a consumer use, a part of roasted coffees were distilled at the temperature of 93-96°C and the pressure of 1-2 bar for the time interval of 18-35 seconds for the 20-40 mg coffee brew (coffee brew-I) whose caffeine component content is low as an espresso coffee; other part of roasted coffees were cracked first and paper filtered by the 93-96°C degree heated water for about 4 to 5 mins like a hand extraction process (coffee brew-II) whose caffeine component content is high. They are as a drip coffee. Coffee brew property was examined from the coffee grounds samples.

Sample mass is measured on the analytical balance Sartorius for weighing up to 520 g maximum with 0.1 or 0.01 mg resolution.

Powder samples then were sealed in transparent tubes with diameter less than 3 mm. For the EPR spectrometer measurement it was used 5 mm diameter quartz tube for the samples.

EPR was measurement done on the SEPR-12 Radio-Spectrometer at the Department of Physics, National University of Mongolia.

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The spectrometer was operated at a frequency of near 9.0 GHz, with a 100 KHz modulation frequency, 0.01 Gs modulation amplitude, a thousand times gain and 100 s time constant.
Experimental results are summarized in the following table 1. In every sample it was registered singlet, low intensity but broad EPR spectrum with g-factor of approximately 2.00 near the 3400 Gs central magnetic field at room temperature (300 K) in a presence of air. EPR spectra parameters as the linewidth (ΔH_{pp}) determined as the difference of field positions of maximum and minimum of the first derivative EPR spectrum, the integral intensity (I_{pp}) as the distance between maximum and minimum of the first derivative EPR spectrum and as well as paramagnetic species concentration as $N_{sam} = \frac{N_{ref} \cdot S_{sam}}{S_{ref}}$, where $S = I_{pp} / 2 \cdot H^2{}_{pp}$ or S_{sam} and S_{ref} are the area of the EPR spectrum, were determined. For the determination of the spin concentration it is measured coal sample EPR spectrum as a reference sample. The concentration of the reference sample is given as $N_{ref} = 4.5 \cdot 10^{17}$ spin.

Table 1. EPR spectra parameters of the studied coffee samples. Coffee samples named by its grown plant country and differ from their roasting degree and grind size (particle size: s – 0.15-0.2 mm; b – 0.5-0.7 mm).

Coffees	**Roasting degree**	**Grind size**	$m_{sam} \cdot 10^{-3}$, gram	**EPR spectra parameters**	
				ΔH_{pp}, Gs	$N_{sam} \cdot 10^{16}$, spin/gram
Mexico	medium	s	7.00	16.94	21.29
Colombia I			9.60	16.66	21.75
Indonesia	dark		6.60	16.87	21.29
Honduras	medium	b	7.40	16.45	17.35
Colombia II			5.20	17.29	20.24
Brazil			8.50	16.87	18.25
Coffee grounds					
Mexico	medium	s	6.40	17.29	17.37
Colombia I			5.60	16.45	19.17
Indonesia	dark		8.30	17.29	16.87
Honduras	medium	b	12.50	8.22	18.11
Colombia II			15.10	17.08	2.65*
Brazil			8.20	17.08	17.67
Coffee bean	non-roast	b	12.20	16.94	16.63

* may be an experimental error

EPR spectra of studied coffees and the coffee grounds are from the carbon centered free radicals as a single line centered around 3400 Gs.
According to the references [3] free radicals can act prooxidative as well as antioxidative, therefore it was evaluated a free radical content as an antioxidant activity of the studied sample.
Grind size was the main dependence factor of the amount of radical concentration, as shown in the fig.1 the free radical concentrations of the first three samples are definitely more than those of bigger particle size samples which are latter three coffee samples.
However, grind size, roasting degree and the coffee brew preparation condition (coffee brew I and II) of the coffee brew has no relation to the free radical concentration.

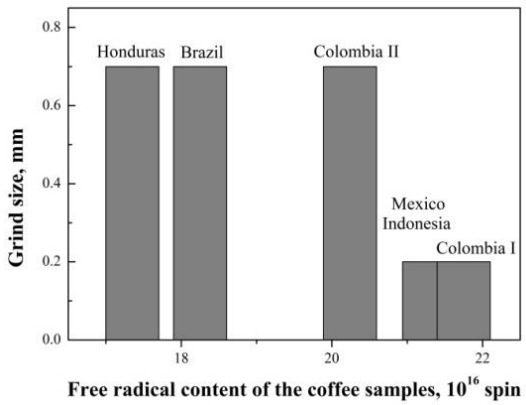

Fig.1 Dependence of coffee grind size on the free radical concentration

There is a well drawn free radical concentration relation between good grind (particle size - s) coffees (Mexico, Colombia I, and Indonesia coffees) and their grounds prepared under the

condition of coffee brew-I. The content of free radical is decreasing after (fig.2) distillation in water at the temperature of around 90^0C. However this correlation has no meaning in poor grind samples (fig.3).

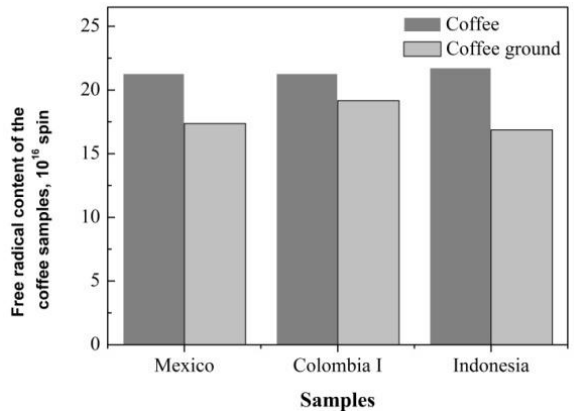

Fig.2 Free radical concentration in well grind (particle size - s) coffee and its ground

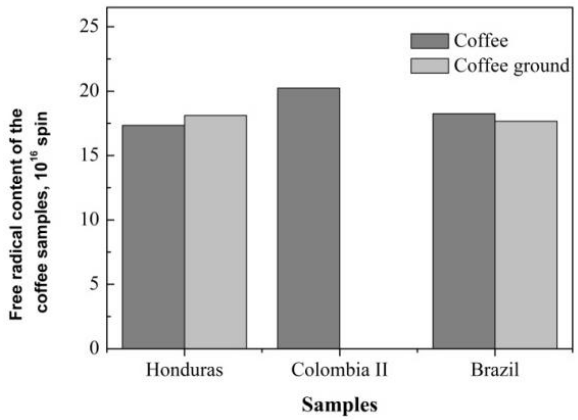

Fig.3 Free radical concentration in poor grind (particle size - b) coffee and its ground

EPR measurement results show that comparing to those of coffee and coffee ground samples roasted at the same degree (medium and dark) in [1-6] and the coal reference sample, the free radical concentration in our samples were significantly low (one order lower than the reference sample radical concentration). Experimental results show that roasting process produces free radicals definitely which is confirmed by the measurement and the evaluation of free radical concentration of only one raw sample as coffee bean, non-roasted. Linewidth of the EPR spectra of the studied samples were significantly broad between 16 to 17 Gs. There is no visible difference between samples EPR spectrum linewidth.

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