Potravinarstvo Slovak Journal of Food Sciences
vol. 11, 2017, no. 1, p. 260-265
doi: https://dx.doi.org/10.5219/794
Received: 27 March 2017. Accepted: 24 April 2017.
Available online: 23 May 2017 at www.potravinarstvo.com

ISSN 1337-0960 (online)

SELECTED PARAMETERS OF ARABICA COFFEE QUALITY AFFECTED BY ITS GEOGRAPHICAL ORIGIN

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ABSTRACT
The aim of this paper was to evaluate selected parameters of Arabica coffee quality. Arabica coffee beans originated from 21 different regions of the world. Parameters of their moisture content, water extract, water extract in dry matter, dry mater, caffeine and caffeine content in dry matter were assessed by the Slovak Technical Standard. Dry matter content ranged from 98.64 to 99.07%, the highest content was measured in sample from Cuba. Minimum dry matter content was detected in coffee beans from Mexico. Caffeine in studied samples ranged from 10 200 mg.kg^{-1} to 13 500 mg.kg^{-1}. The lowest caffeine content was determined in Panama coffee, the highest was found in the sample from Indonesia. The results of moisture content and caffeine in dry mater were evaluated by the Food Code of the Slovak Republic and all observed parameters in the coffee beans meet the maximum levels given in legislation. By statistical procesing it can be seen that coffee samples originating from Ecuador, Indonesia and Nepal were similar in parameters of caffeine content and caffeine in dry matter. Other similar samples originating from Cuba, Peru, Ethiopia and Panama were statistically similar at dry matter content. Special statistical group was coffee from Salvador at the parameters of water extract and water extract in dry matter.

Keywords: coffee; Arabica; quality; caffeine; dry matter

INTRODUCTION
Coffee is one of the most popular beverages in the world. It is consumed for its refreshing and stimulating properties. Coffee is very common plant that grows throughout the tropical and subtropical zone. It is cultivated in the nutritious, and particularly acidic soil of plantations **(Veselá, 2010)**. There are approximately 60 kinds of coffee, but from the economic point of view just three of them are important: Coffea arabica (70-75 % production), Coffea robusta- canephora and Coffea liberica (**Burešová, 2016; Fodran et at., 2011**). Arabica grows at higher altitudes. It is more demanding for planting, the first harvest it can have after 6 years of growing. Ideal temperature of cultivation is between 15 – 24 °C. Arabica contains lower percentage of caffeine than Robusta. To cultivate Robusta is less difficult than Arabica. The first harvest of Robusta is after 2 – 3 years. Robusta contains more caffeine than arabica, and has a bitter taste **(Veselá, 2010)**. The quality of coffee depends on the moisture, origin, price, biochemical and taste qualities. It should be noted that each country can define its organoleptic properties **(Leroy et al., 2006)**. Physical properties, chemical composition and properties of the drink prepared from roasted ground coffee of each species are different **(Farah, 2012)**. Due to its commercial importance, the detection of impurities and foreign matters in coffee has been a constant concern in fraud verification **(De Moura Ribeiro et al., 2017)**.

Coffee is a complex mixture of compunds including carbohydrates, lipids, crude protein, vitamins, minerals, alkaloids, phenolic compounds and melanoidins. As biologically active class components in coffee are generally considered caffeine, chlorogenic acid and diterpenes (cafestol and kahweol) **(Williamson, 2012)**. The best known sources of caffeine are coffee, cocoa beans, nuts and tea. Coffee beans contain between 0.8 and 2.8% of caffeine, depending on the type and origin. The caffeine content in coffee beans during roasting is not significantly affected **(Phan et al., 2012)**. By roasting of the beans the water evaporates and aroma is formed (**Burešová, 2016**).

According to Slovak legislation, coffee is a product which is obtained by roasting of green coffee. The content of caffeine must be present in the amount of at least 0.6 percent in the dry matter. Caffeine is an alkaloid known as the stimulant of the central nervous system.

The aim of this work was to compare the selected chemical parameters of Arabica coffee quality, which originated from different geographical areas of the world.

MATERIAL AND METHODOLOGY

Observed material were Arabica coffee beans (Fig.1) which originated from 21 different geographical areas of the world: Nicaragua (1), Colombia (2), India (3) Mexico (4), Salvador (5), Brazil (6) Guatemala (7), Cuba (8), Costa Rica (9), Ethiopia (10), Indonesia (11), Kenya (12), Peru (13), Dominican Republic (14), Papua New Guinea (15), Honduras (16), Ecuador (17), Jamaiva Blue Mountain (18), Indonesia Kopi Luwak (19), Nepal Mounth Everest (20), Panama (21).

Figure 1 Coffee beans of Arabica originating from different countries **(Hambálková, 2013)**.

Coffee beans were roasted and the subject for determination of the following parameters: moisture content, water extract and water extract in dry matter, caffeine content and caffeine in dry matter, the content of dry matter.

Dry mater determination (Slovak Technical Standard 580114)

3 g of the sample was placed in a vacuum oven (pressure 5.0 bar). Under the flow, the sample was dried for 16 hours in a vacuum oven at 70 °C. Dry matter content was calculated as a percentage of the weight of the sample. The result was calculated as the mean of the two determinations.

Determination of caffeine (Slovak Technical Standard 580113-21)

0.5 grams of ground coffee was weighed and transferred to 100 cm^3 flask. To the flask were added 2 g of pure quartz sand and 5 cm^3 of ammonia solution, mixed together and were allowed to stand for 3 minutes. Flask was placed for 2 minutes in a boiling water bath.

Alkaline and acidic column were used for determination according to given procedure. Then purification and extraction of caffeine were performed. Extinction of obtained solution was measured spectrophotometrically against chloroform. Wavelength 276 nm was applied.The content of caffeine in the test solution is determined from the measured values using a calibration curve.

Caffeine content in dry matter (%) was calculated using the formula (1):

$$X = \frac{1000 \cdot c}{m_0 \cdot (100 - w)} \cdot 100 \cdot 100 \qquad (1)$$

Where:
- c is the concentration of caffeine in the tested solution (obtained from the calibration curve), $g.cm^{-3}$;
- m_0 is weight of sample in g;
- w is moisture in %.

Determination of moisture (Slovak Technical Standard 580113)

5 g of coffee beans was weighed and was crushed in purpose to 100% of the particles passed through the sieve of size 2.0 mm and 80% of the particles on the sieve size 1.0 mm. The sample was placed in an oven at (105 ±1) °C. The sample was dried for 5 hours. Drying was repeated every 30 minutes as long as the difference between two measures is not more than 0.1%.

Water extract determination (Slovak Technical Standard 580113)

Water extract is the amount of substances which, under certain conditions are coming to the water solution. The milled coffee is boiled to reflux condenser, the obtained suspension is filtered and by the evaporation of a filtrate are determined water-soluble substances.

Statistical processing

Correlation coefficients among attributes were calculated by the Principal component analysis (PCA) at significance level (p <0.05). All obtained results, including the graphical presentations, were processed using MS Excel (2010) and XLSTAT 2014 (Addinsoft, NY, USA) package program.

Our hypotesis was to characterise the selected chemical parameters of coffee samples in term of their possible variability associated with different origin of coffee.

RESULTS AND DISCUSSION

Production of quality coffee is characterized by climatic conditions and clearly shows that climate is an important factor in determining the quality of coffee **(Da Silva et al., 2005)**.

The dry matter content of our samples ranged from 98.64% to 99.07%. The highest content of dry matter (99.07%) was measured in sample originating from Cuba. Minimum dry matter content of 98.64% was detected in of coffee beans from Mexico. Dry matter content decreased in the following order: Cuba (99.07%), Honduras (98.96%), Peru (98.93%), Ethiopia (98.93%), Salvador (98.92%); Indonesia (98.88%), Papua New Guinea (98.87%), Panama Geisha (98.85%), Jamaiva Blue Mountain (98.84%), Kenya (98.82%), Costa Rica (98,82%), Brazil (98.81%), Nicaragua (98.79%), the Dominican Republic (98.77%), Indonesia Kopi Luwak (98.73%), Colombia (98.71%), India (98.7%), Nepal Mounth Everest (98.69%), Guatemala (98.67%), Ecuador (98.65%), Mexico (98.64%). **Hoffmann (2014)** indicates that coffee beans have initial moisture content approx. 60% and by the drying process they should be dried to the moisture content 11 – 12%, to avoid their spoliage. Also by **Burešová (2016)** green coffee contains approx. 12 % water. By roasting water evaporates (to 3 % content). As it was expected, very strong negative correlation was observed between dry matter and moisture. The moisture content of the samples ranged from 0.93% to 1.36%. Correlation coefficients were statistically different at significance level (p <0.05). Low moisture content 0.93% was measured in the coffee from Cuba. The highest value was measured in the sample from Mexico (1.36%).

Table 1 Observed chemical parameters of Arabica coffee quality.

Origin/Parameter	Caffeine ($mg.kg^{-1}$)	Caffeine in DM (% DM)	Dry matter (%)	Water extract (%)	Water extract in DM (%)
Nicaragua	12100	1.21	98.79	30.87	31.25
Colombia	11900	1.21	98.71	31.2	31.61
India	12600	1.28	98.7	31.37	31.78
Mexico	12000	1.22	98.64	32.05	32.49
Salvador	11400	1.15	98.92	38.81	39.23
Brazil	12300	1.24	98.81	29.67	30.03
Guatemala	12000	1.22	98.67	29.98	30.38
Cuba	11800	1.19	99.07	29.41	29.69
Costa Rica	12600	1.28	98.82	31.47	31.85
Etiopia	10900	1.1	98.93	30.4	30.73
Indonesia	12500	1.26	98.88	31.1	31.45
Kenya	11500	1.16	98.82	30.3	30.66
Peru	11400	1.15	98.93	29.45	29.77
Dominican republic	11800	1.19	98.77	30.12	30.49
Papua New Guinea	12100	1.22	98.87	30.55	30.9
Honduras	11900	1.2	98.96	29.83	30.14
Ecuador	12200	1.24	98.65	31.28	31.71
Jamaiva Blue Mountain	12600	1.28	98.84	30.28	30.64
Indonesia Kopi Luwak	13500	1.37	98.73	30.53	30.92
Nepal Mounth Everest	13100	1.33	98.69	31.04	31.45
Panama Geisha	10200	1.03	98.85	29.18	29.52

Table 2 Factor scores of centroids for Arabica coffee in PC1 vs. PC2 dimension and their squared cosines.

	F1		F2	
Parameter/Origin	**Factor score**	**cos^2**	**Factor score**	**cos^2**
Nicaragua (1)	0.2324	**0.4978**	-0.0321	0.0095
Colombia (2)	0.8391	0.4027	0.2207	0.0279
India (3)	1.4905	**0.7644**	0.2573	0.0228
Mexico (4)	1.6684	**0.5052**	0.8077	0.1184
Salvador (5)	-1.2801	0.0441	5.9438	**0.9500**
Brazil (6)	0.3120	0.0863	-0.9621	**0.8209**
Guatemala (7)	1.2520	0.4256	-0.7045	0.1348
Cuba (8)	-2.7423	**0.6176**	-0.9942	0.0812
Costa Rica (9)	0.8305	0.4002	0.2800	0.0455
Ethiopia (10)	-2.6503	**0.9577**	-0.0929	0.0012
Indonesia (11)	0.0563	0.0019	0.0496	0.0015
Kenya (12)	-0.8373	**0.5475**	-0.3209	0.0804
Peru (13)	-2.0276	**0.8333**	-0.9003	0.1643
Dominican Republic (14)	0.0149	0.0003	-0.5299	0.3481
Papua New Guinea (15)	-0.4436	0.3070	-0.2634	0.1083
Honduras (16)	-1.5824	**0.5906**	-0.7314	0.1261
Ecuador (17)	1.7999	**0.7189**	0.2017	0.0090
Jamaiva Blue Mountain (18)	0.5664	0.1713	-0.5875	0.1843
Indonesia (19)	2.8175	**0.7720**	-0.6283	0.0384
Nepal Mounth Everest (20)	2.6629	**0.9613**	-0.1713	0.0040
Panama (21)	-2.9793	**0.5963**	-0.8422	0.0477

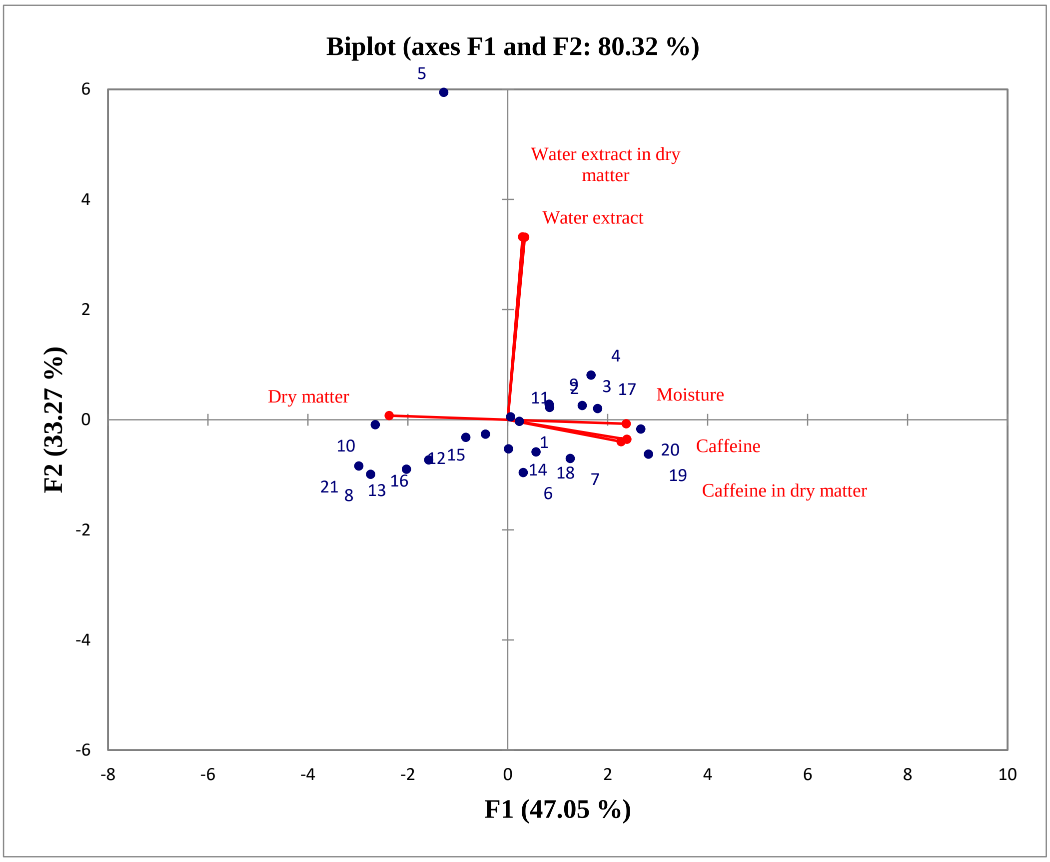

Figure 2 Map of PC1 and PC2 with observations. The labels correspond to sample notation given in the Table 2.

By the **Law 309/2015** of the Slovak republic the moisture content of the coffee should be max. 5%. Following this requirement, all our samples were in accordance with legislation. By **Leroy et al. (2006)** moisture is important indicator of quality coffee. The high moisture content of the grains results in the loss of material and the physical and sensory problems. Water evaporation caused by roasting, accounts for 40 % weight reduction of coffee bean (**Fodran et al., 2011**).

Water extract content of our samples ranged from 29.18% to 38.81%. Minimum content of it was determined in Panama coffee. The highest content (38.81%) was determined in sample from Salvador. The content of water extract in dry matter ranged from 29.52% to 39.23% (Table 1). The lowest content of the water extract in dry matter (29.52%) was confirmed in samples from Panama again. The highest value of water extract in dry matter 39.23% was confirmed in samples from Salvador.

Caffeine and important constituents of coffee, have been shown to possess biological activities that highlight a possible mechanistic link to the pathology of depression. Bioactive coffee constituents have been shown to positively influence various parameters, including inflammation, oxidative stress and behaviour, associated with the neuroinflammatory hypotheses of depression in both in vitro and in vivo studies (**Hall et al., 2015**). **Dziki et al. (2015)** presented possibilities of using green coffee beans from Ethiopia, Kenya, Brazil and Colombia as a functional additive. Bread enriched with green coffee beans possessed higher antiradical activity than control samples.

Our observed coffee samples ranged in caffeine content from 10 200 $mg.kg^{-1}$ to 13 500 $mg.kg^{-1}$. The lowest caffeine content was found in Panama coffee, the highest was found in the sample from Indonesia. Caffeine decreases in the following order: Indonesia Kopi Luwak (13 500 $mg.kg^{-1}$), Nepal Mounth Everest (13 100 $mg.kg^{-1}$), Blue Mountain Jamaiva (12 600 $mg.kg^{-1}$), Costa Rica (12 600 $mg.kg^{-1}$), India (12 600 $mg.kg^{-1}$), Indonesia (12 500 $mg.kg^{-1}$), Brazil (12 300 $mg.kg^{-1}$), Ecuador (12 200 $mg.kg^{-1}$), Papua New Guinea (12 100 $mg.kg^{-1}$), Nicaragua (12 100 $mg.kg^{-1}$), Guatemala (12 000 $mg.kg^{-1}$), Mexico (12 000 $mg.kg^{-1}$), Honduras (11 900 $mg.kg^{-1}$), Colombia (11 900 $mg.kg^{-1}$), Cuba (11 800 $mg.kg^{-1}$), Dominican Republic (11 800 $mg.kg^{-1}$), Kenya (11 500 $mg.kg^{-1}$), Peru (11 400 $mg.kg^{-1}$), Salvador (11 400 $mg.kg^{-1}$), Ethiopia (10 900 $mg.kg^{-1}$), Panama (10 200 $mg.kg^{-1}$).

By statistical procesing (Figure 2) it can be noted that samples of coffee originating from Ecuador, Indonesia and Nepal (19, 20, 17) were similar at the parameters of caffeine content and caffeine in dry matter. Other group of samples originating from Cuba, Peru, Ethiopia, Panama (8, 13, 10, 21) were statistically similar at dry matter content.

Special sample was coffee from Salvador (5) in parameter of water extract and water extract in dry matter.

As it was expected statistically there was observed a strong positive correlation between caffeine and caffeine in dry matter and water extract and water extract in dry matter. Correlation coefficients were statistically different at significance level (p <0.05). Caffeine content in dry matter of our coffee samples ranged from 1.03% to 1.37%. The lowest caffeine content in dry matter 1.03%, was found in the sample from Panama. The highest content of 1.37% was determined in the sample from Indonesia. By the **Law 309/2015 of the Slovak republic** the caffeine content in dry matter should be min. 0.6%. Following this requirement all our samples were in accordance with legislation. Content of caffeine and chlorogenic acid in commercial coffee brands were determined by **Phan et al. (2015)** in Czech, Vietnamese and Brazilian ground roasted coffee brands. The lower content of caffeine was observed in Vietnamese coffees. Among our countries the sample from Panama was the lowest in caffeine, water extract, caffeine in dry matter as well.

Noguchi et al. (2015) performed a study in healthy volunteers with a cup of either caffeinated or decaffeinated coffee. Caffeinated coffee intake significantly elevated blood pressure and decreased finger blood flow as compared with decaffeinated coffee intake. There was no significant difference in heart rate between caffeinated and decaffeinated coffee intake. Caffeine in a cup of coffee enhances microvascular function in healthy individuals.

Table 2 presents factor scores and squared cosines of our samples, which are the coordinates and representation qualities, respectively, of the centroids in the 2-D space. Results in bold correspond for each observation to the factor for which the squared cosine is the largest. All these variables from table 2 are placed in the loading plot (Figure 2). The first two principial components (PC) explain more than 80% of total variation for analyzed variables. **Šnirc et al. (2016)** found the first five PC analyzing chemical and technological parameters in red deer meat explained more than 85% of total variability of those measurements.

The PC1 in our case, accounting for 47.05% of the inertia (Figure 2), contrasted dry matter with moisture, and caffeine content and caffeine in dry matter whereas PC2, explaining 33.26% of the inertia, clearly reflected the different content of water extract and water extract in dry matter for tested coffee variables.

CONCLUSION

We can conclude that our samples of Arabica coffee originating from the different places of the world were affected by climatic conditions at observed parameters of quality. Among selected 21 countries, the sample from Panama was the lowest in caffeine content, water extract and caffeine in dry matter as well.

However, all observed samples of coffee beans were in accordance with the required legislational requirements, regarding their moisture content and caffeine content in dry matter as well.

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