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Effect of cultivation region on the quality of Arabica coffee beans (Red Bourbon variety)

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INTRODUCTION & AIM

Caffeine is one of the most well-known biologically active compounds in coffee beans, and its content largely determines the taste and stimulating properties of the drink. However, the amount of caffeine in beans can vary significantly depending on growing conditions, even within the same coffee variety. The growing global demand for coffee and the current market dynamics emphasize the necessity to investigate how the origin of coffee beans influences beverage quality. Arabica beans, particularly the Red Bourbon variety, are known to exhibit variations in chemical composition, sensory characteristics, and technological behavior depending on their cultivation environment.

The study aimed to evaluate the physicochemical and sensory properties of Arabica Red Bourbon beans sourced from distinct geographic regions, considering factors such as altitude and local environmental conditions.

The sensory characteristics of the resulting beverages were evaluated using the capping method, and water activity, density, moisture content, colour, pH, extractivity and caffeine content were determined.

Samples. Green coffee beans of the 2023 harvest were collected from four regions: Rwanda (R (code 11-23-10), 1500 m), Colombia (Col (code 07-23-32), 1850 m), Congo (Con (code 11-23-07), 1800 m), and El Salvador (S (code 03-24-44), 1500 m). The selection ensured diversity in terroir while maintaining consistency in the variety.

METHOD

Green coffee beans were roasted in a Kaffelogic Nano 7 electric roaster using a standardised temperature-time profile. The colour of the roasted beans was determined using a Lighttells CM-100 Plus Roast Analyzer infrared coffee roasting analyser. Total dissolved solids (TDS) and extraction yield (EXT) were measured using a DiFluid R2 Extract device. Before conducting analytical studies, each coffee sample was ground in a Mahlkönig Omnia coffee grinder with a set distance between the burrs of 450 nm.

For organoleptic evaluation (cupping method), the mass of ground coffee was standardised to 12 g, which was weighed in special tasting cups. Extraction was carried out by pouring 200 ml of hot distilled water at a temperature of 95 °C over the samples, followed by intensive stirring with a stream of water. At the fourth minute of extraction, the crust was broken, after which the drink was considered ready for organoleptic evaluation.

The study also recorded the mass fraction of moisture in green and roasted coffee. Moisture measurement allows you to control the quality and stability of storage and predict the be haviour of the beans during roasting. An EM 120-HR moisture analyser was used to determine moisture content.

During roasting, coffee beans typically lose 12 to 20%of their weight. For light roasting, this loss is approximately 12–14%, for medium roasting - 15–17%, and for dark roasting - 18–20% or even more in the case of deep roasting.The primary reasons for weight loss are the evaporation of moisture, the release of volatile compounds, and the thermal decomposition of organic substances. Green coffee contains approximately 10–12% moisture, which evaporates almost completely duringthe heat treatment process. In addition, gases are released from the beans, including carbon dioxide, organic acids and aromatic substances.

RESULTS & DISCUSSION

The most moist grains were Col and R (3.4%), while samples Con (3.1%) and S (2.0%) had lower moisture content during roasting. However, the greatest moisture loss during roasting was observed for samples S and R (13.4%), and the least for sample 7 – 9.3%. The water activity in green grains Con, R and S was within the normal range of 0.50-0.55, and for sample Col it was slightly elevated at 0.56. However, after roasting, this indicator fell within the acceptable range (0.18-0.30) for all grain samples.

For green coffee, the optimal water activity level is around 0.50–0.55, and for roasted coffee, it is 0.18–0.30. Controlling this parameter is important for preventing mould growth and spoilage during storage, ensuring uniform roasting, preserving flavour properties, and selecting the right packaging materials.

Table 1. Water activity (a_w) in coffee beans

Sample code	Green grain		Roasted grain	
	a_w sample measured on 06.12.24, %	a_w sample measured on 07.03.25, %	a_w of the roasted sample 15.11.24, %	a_w of the roasted sample 06.03.25, %
Con (11-23-07)	---	0.5163	0.2872	0.1212
R (11-23-10)	0,5611	0.5343	0.2846	0.1312
Col (07-23-32)	0,5898	0.5642	0.2736	0.1189
S (03-24-44)	0,5666	0.5377	0.2513	0.1053

A decrease in the a_w of green coffee beans during storage is a positive change for quality preservation, as it moves the beans closer to or within the optimal range of 0.45-0.55 a_w. This decrease is most likely caused by storing the beans in an environment with lower relative humidity than their initial equilibrium a_w and by a decrease in the ambient temperature.

For roasted coffee beans, the optimal a_w for storage is significantly lower than for green coffee, ranging from approximately 0.18 a_w to 0.30 a_w. This low level is critical for mini mising oxidation and the loss of volatile aromatic compounds that give coffee its flavour. It effectively slows down the ageing and bitterness processes, prevents the continuation of Maillard reactions and ensures that microorganisms do not grow.

The a_w of roasted coffee beans increases during storage due to their hygroscopic nature and exposure to an environment with higher relative humidity. An increase in the a_w of roasted coffee is a negative factor and accelerates lipid oxidation (leading to rancidity and a musty taste), the loss of volatile aromatic compounds (aromas) and the development of undesirable flavours (paper, wood). This significantly reduces the shelf life of coffee and impairs its quality in the cup.

After preparing the beverage, we determined the TDS and EXT. The EXT range for most filter coffee brewing methods, according to SCA recommendations, is 18%–22%. For our samples, it ranged from 20.03% to 21.21%, and TDS from 1.23% to 1.30%. There was a decrease in TDS and EXT values in coffee beverages made from beans stored for three months compared to beans stored for one week, which is a direct result of coffee degradation over time. This is due to the breakdown and evaporation of volatile aromatic compounds that are key to taste and aroma, as well as lipid oxidation and other chemical changes that reduce the quantity and quality of soluble components. The loss of these substances means that it is not possible to extract as many soluble substances from long-stored beans as from fresh ones, resulting in a less rich and intense beverage.

pH measurements showed that sample S was the least acidic (pH = 5.04), and sample Con had the highest TDS. Grapes from high-altitude regions tend to have higher acidity (lower pH) due to slower ripening, which promotes the accumulation of organic acids.

The unusually high caffeine content in the Colombian sample particularly for Arabica, especially at high altitude suggests the likely influence of genetic variation or specific stress factors in this terroir, which warrants further research. The data obtained confirm the significant variability of bean and beverage characteristics even within a single species (Arabica), highlighting the importance of unique terroir factors and processing methods.

CONCLUSION

The conducted research confirmed that the geographical origin of Arabica Red Bourbon beans significantly impacts their physicochemical and sensory attributes. Variations in moisture, acidity, and caffeine content were observed among the samples, despite a consistent roasting profile.

FUTURE WORK / REFERENCES

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