Investigation of the caffeine content of Honduran Coffee varieties

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Abstract

This study, the result of a collaboration between IHCAFE, CDR, and the Accademia del Caffè Espresso, analyzes the caffeine content of the main varieties grown in Honduras, ranging from Coffea arabica to Robusta, to modern hybrids. Through spectrophotometric analysis conducted with the CDR CoffeeLab® system on green coffee samples, the research evaluates the relative importance of three key variables: genetic profile, cultivation altitude, and bean aging. The article discusses the data to clarify which of these factors are truly determining the concentration of the alkaloid, offering new evidence on the relationship between terroir and chemical composition.

Introduction

Caffeine is one of the main secondary metabolites of coffee, playing a key role in both the plant's defense against insects and pathogens and in the beverage's stimulant properties for the consumer. The caffeine concentration in green coffee, and consequently also in the roasted product, is influenced by several factors, including the botanical species, variety, environmental conditions, and agronomic practices. In particular, *Coffea canephora* (Robusta) is known to contain significantly higher caffeine levels than *Coffea arabica*, while hybrids generally have intermediate values, depending on the degree of hybridization.

In addition to genetics, cultivation altitude has been frequently studied as a potential modulator of caffeine content. However, the literature on this topic reports conflicting results: in some cases, increasing altitude is associated with higher caffeine levels, while in other studies, no significant differences are observed. These discrepancies may arise from the lack of rigorous control over the varieties and genetic backgrounds of the analyzed samples, as well as from differences in local environmental conditions.

This study, conducted by the **Honduran Coffee Institute (IHCAFE)** in collaboration with **CDR srl** and the **Accademia del Caffè Espresso** , represents a unique analysis of its kind, as it examines the main **coffee varieties** grown in **Honduras** , including **Arabica** , **Robusta ,** and **hybrids** , with the aim of determining the actual caffeine content of the analyzed samples. The samples, sourced from different altitudes and processed using conventional washed fermentation, allow for an integrated evaluation of the influence of genetics and growing conditions on caffeine content, with particular attention to hybrids and the comparison between Arabica and Robusta.

Analytical procedure for the determination of Caffeine

The **determination of caffeine content** was performed using the **CDR CoffeeLab®** analysis system , which uses a spectrophotometric method.

The green coffee samples, after removing the parchment, were finely ground and sieved until a homogeneous powder was obtained. To prepare the sample, 5 g of the sample was mixed with 50 ml of distilled water and 1 g of calcium carbonate; the solution was stirred for 10 minutes and then allowed to settle. For the final analysis, 1 ml of the supernatant was removed and mixed with 1 ml of a specific extracting solution, then shaken vigorously and centrifuged. The spectrophotometric reading (*End Point*) was performed covering a measurement range of 0.1–4.0%.

Results

Variety Effect

For this study, several coffee varieties were selected from a single location, the **Las Lagunas Research and Training Center**, located in **Marcala**, **La Paz** (1,450 m above sea level), to evaluate **the effect** of **genetics** on **caffeine content under the same environmental conditions**. All samples were processed using the same fermentation method (conventional washed), thus eliminating the fermentation process from the variables potentially capable of influencing the analytical results.

Caffeine values in **green coffee**, expressed as a **% of the dry weight of the green coffee**, reported in the following table represent the average of four independent samples for each variety, in order to ensure greater robustness and consistency of the data.

No	Variety	Caffeine (%)
1	Nemaya	2.0
2	Ihcafe-90	1.9
3	Lempira	1.7
4	Ihcatu-75	1.5
5	Parainema	1.4
6	Obata	1.4
7	Gueysha	1.3
8	Typical	1.4
9	Catuai	1.4

Table 1: Caffeine content in green coffee of different varieties

At the same altitude, the data show a clear gradient in caffeine content in green coffee: the Robusta variety has the highest values, followed by hybrids with intermediate values, while Arabica varieties have the lowest values. The Robusta variety (Nemaya) has the highest caffeine content, at around 2.0%, while pure Arabica varieties (Geisha, Typica, Catuai) show lower and more concentrated values (1.3–1.4%). Hybrids (IHCAFE-90, Lempira, IHCATÚ-75, Parainema) fall into an intermediate range (1.4–1.9%).
This trend is fully consistent with the literature, which identifies caffeine as a metabolite strongly determined by genetic background, with higher average values in *Coffea canephora* than in *Coffea arabica*. Hybrids tend to maintain higher caffeine levels than pure Arabica, depending on the degree of genetic introgression. In this context, the relatively high value observed for IHCAFE-90 (1.9%) is consistent with its classification as a hybrid and with the hypothesis of significant genetic inheritance from Robusta, and the same is true for the other varieties analyzed.

Altitude effect

To evaluate the effect of cultivation altitude on the caffeine content of green coffee, samples from two different locations were also analyzed:

- Las Lagunas Research and Training Center (CIC-LL), Marcala, La Paz – 1,450 m above sea level
- Carlos Alberto Bonilla Research and Training Center (CIC-CAB), Campamento, Olancho – 800 m above sea level

In order to maintain constant processing conditions, all samples were re-processed by conventional washed fermentation.
The caffeine values in green coffee reported in the following table represent the average of four independent samples for each variety, in order to ensure greater robustness and consistency of the data.

No	Location	Variety	Caffeine (%)
1	Marcala	Lempira	1.7
2	Marcala	Parainema	1.6
3	Marcala	Obata	1.4
4	Campamento	Lempira	1.5
5	Campamento	Parainema	1.5
6	Campamento	Obata	1.4

Table 2: Caffeine content in green coffee of 3 varieties at different altitudes

Comparisons between Arabica samples grown at approximately 700 m and 1600 m do not reveal a linear or systematic relationship between altitude and caffeine content in green coffee. For some varieties (e.g., Lempira and Parainema), a slight increase in caffeine is observed at higher altitudes, while for others (e.g., Obata) the values remain substantially unchanged.
These results are consistent with numerous studies reporting the absence of a universal correlation between altitude and caffeine, especially within *C. arabica*. Although altitude influences plant metabolism (through temperature, ripening rate, and physiological stress), its effect on caffeine appears to depend on the variety and local environmental conditions, rather than the altitude itself.

Effect of aging

Green coffees, properly stored (cool, dry, dark place) were analyzed after 6 months to evaluate the effect of aging on caffeine levels. The results obtained are in the table:

No	Variety	Caffeine in fresh coffee (%)	Caffeine in aged coffee (%)
1	Nemaya	2.0	2.0
2	Ihcafe-90	1.9	1.9
3	Lempira	1.7	1.7
4	Ihcatu-75	1.5	1.5
5	Parainema	1.4	1.4
6	Obata	1.4	1.4
7	Gueysha	1.3	1.3
8	Typical	1.4	1.4
9	Catuai	1.4	1.4

Table 3: Caffeine content in coffee after 6 months of storage.

The results show that, for all varieties analyzed, the caffeine content of green coffee remained unchanged after six months of storage. The values measured in fresh coffee matched exactly those found in aged coffee, indicating that, under the conditions used (cool, dry, and protected from light), aging had no effect on caffeine concentration.
This result suggests that caffeine is a chemically stable component in green coffee and does not undergo significant degradation over time, at least in the period considered and in the absence of unfavorable environmental factors such as humidity, high temperatures, or exposure to light.

Conclusions

The results obtained with **CDR CoffeeLab®** highlight how the **caffeine content** in green

coffee is strongly influenced by the **genetics of the plant** , while the cultivation altitude, in the range considered, has a secondary and non-unique effect.
The choice of coffee variety, especially the **degree of crossbreeding with *Coffea canephora* (Robusta)**, is a more effective and reliable tool than the choice of altitude alone in influencing the caffeine content of green coffee. From a management perspective, this means that focusing on specific varieties and hybrids allows for more direct and consistent control of caffeine content, compared to strategies based solely on growing area and altitude.

Finally, the results suggest **that altitude affects caffeine content mainly indirectly**, through factors such as temperature, fruit ripening time and plant stress conditions, rather than acting as a direct and decisive factor.

Bibliography

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3. Worku, M., et al. (2018). *Effect of altitude on caffeine and other biochemical contents of coffee beans. Journal of Agricultural and Food Chemistry*

Useful Links

· Honduran Coffee Institute (IHCAFE)
· Espresso Academy
· Method for the determination of caffeine
· CDR CoffeeLab® : coffee analysis from fruit to cup