*Article*

# Raman spectroscopic and sensory evaluation of cocoa liquor prepared with Ecuadorian cocoa beans treated with gamma irradiation or induced electromagnetic field fermentation.

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## Supplementary Material

**Table S1.** Time treatment, nominal dose, dosimeter readings, and DUR for the irradiated National cocoa beans.

| Variety | EPR Holder used | Irradiation time (h) | Nominal Dose (kGy) | A (kGy) | | | B (kGy) | | | C (kGy) | | | D (kGy) | | | DUR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Dosimeter Read. 1 | Dosimeter Read. 2 | Mean | Dosimeter Read. 1 | Dosimeter Read. 2 | Mean | Dosimeter Read. 1 | Dosimeter Read. 2 | Mean | Dosimeter Read. 1 | Dosimeter Read. 2 | Mean | |
| National | PX063 | 1.22 | 0.10 | 0.10 | 0.10 | 0.10 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.09 | 0.09 | 0.09 | 1.22 |
| | PX063 | 2.43 | 0.20 | 0.21 | 0.21 | 0.21 | 0.23 | 0.23 | 0.23 | 0.22 | 0.22 | 0.22 | 0.18 | 0.18 | 0.18 | 1.28 |
| | PX063 | 3.65 | 0.30 | 0.32 | 0.32 | 0.32 | 0.34 | 0.34 | 0.34 | 0.33 | 0.33 | 0.33 | 0.27 | 0.27 | 0.27 | 1.26 |
| | PX063 | 5.48 | 0.45 | 0,40 | 0.40 | 0.40 | 0.46 | 0.46 | 0.46 | 0.44 | 0.44 | 0.44 | 0.37 | 0.37 | 0.37 | 1.24 |
| | PX063 | 7.30 | 0.60 | 0.63 | 0.63 | 0.63 | 0.67 | 0.67 | 0.67 | 0.65 | 0.65 | 0.65 | 0.53 | 0.53 | 0.53 | 1.26 |
| | PX063 | 9.12 | 0.75 | 0.69 | 0.69 | 0.69 | 0.79 | 0.79 | 0.79 | 0.80 | 0.80 | 0.80 | 0.61 | 0.61 | 0.61 | 1.31 |
| | PX063 | 12.13 | 1.00 | 1.07 | 1.07 | 1.07 | 1.14 | 1.14 | 1.14 | 1.07 | 1.07 | 1.07 | 0.92 | 0.92 | 0.92 | 1.24 |
| | PL | 24.67 | 2.00 | 2.47 | 2.46 | 2.47 | 2.81 | 2.79 | 2.80 | 2.57 | 2.56 | 2.57 | 2.21 | 2.21 | 2.21 | 1.27 |
| | PH0156 | 36.93 | 3.00 | - | - | - | 3.05 | 3.02 | 3.04 | 2.92 | 2.93 | 2.93 | - | - | - | 1.23 |
| | PL | 36.93 | 3.00 | 2.75 | 2.76 | 2.76 | - | - | - | - | - | - | 2.49 | 2.47 | 2.48 | |

**Table S2.** Time treatment, nominal dose, dosimeter readings, and DUR for the irradiated CCN-51 cocoa beans.

| Variety | EPR | Irradiation time (h) | Nominal Dose (kGy) | A (kGy) | | | B (kGy) | | | C (kGy) | | | D (kGy) | | | DUR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Holder used | | | Dosimeter Mean 1 | Dosimeter Read. 2 | Mean | Dosimeter Read. 1 | Dosimeter Read 2 | Mean | Dosimeter Read. 1 | Dosimeter Read. 2 | Mean | Dosimeter Read. 1 | Dosimeter Read. 2 | Mean | |
| CCN-51 | PX063 | 1.22 | 0.10 | 0.11 | 0.11 | 0.11 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.09 | 0.09 | 0.09 | 1.33 |
| | PX063 | 2.43 | 0.20 | 0.24 | 0.24 | 0.24 | 0.29 | 0.29 | 0.29 | 0.29 | 0.29 | 0.29 | 0.22 | 0.22 | 0.22 | 1.32 |
| | PX063 | 3.58 | 0.30 | 0.26 | 0.32 | 0.29 | 0.32 | 0.32 | 0.32 | 0.30 | 0.30 | 0.30 | 0.24 | 0.24 | 0.24 | 1.33 |
| | PX063 | 5.47 | 0.45 | 0.48 | 0.48 | 0.48 | 0.54 | 0.54 | 0.54 | 0.52 | 0.52 | 0.52 | 0.41 | 0.41 | 0.41 | 1.32 |
| | PX063 | 7.28 | 0.60 | 0.65 | 0.65 | 0.65 | 0.68 | 0.68 | 0.68 | 0.63 | 0.63 | 0.63 | 0.51 | 0.51 | 0.51 | 1.33 |
| | PX063 | 9.12 | 0.75 | 0.72 | 0.72 | 0.72 | 0.81 | 0.81 | 0.81 | 0.80 | 0.80 | 0.80 | 0.59 | 0.59 | 0.59 | 1.37 |
| | PX063 | 12.15 | 1.00 | 1.07 | 1.07 | 1.07 | 1.23 | 1.23 | 1.23 | 1.21 | 1.21 | 1.21 | 0.94 | 0.94 | 0.94 | 1.31 |
| | PL | 24.67 | 2.00 | 2.42 | 2.42 | 2.42 | 2.81 | 2.84 | 2.83 | 2.67 | 2.63 | 2.65 | 2.15 | 2.16 | 2.16 | 1.31 |
| | PH0156 | 36.85 | 3.00 | 2.93 | 2.93 | 2.93 | 3.18 | 3.20 | 3.19 | 3.29 | 3.37 | 3.33 | - | - | - | 1.17 |
| | PL | 36.85 | 3.00 | - | - | - | - | - | - | - | - | - | 2.84 | 2.84 | 2.84 | |

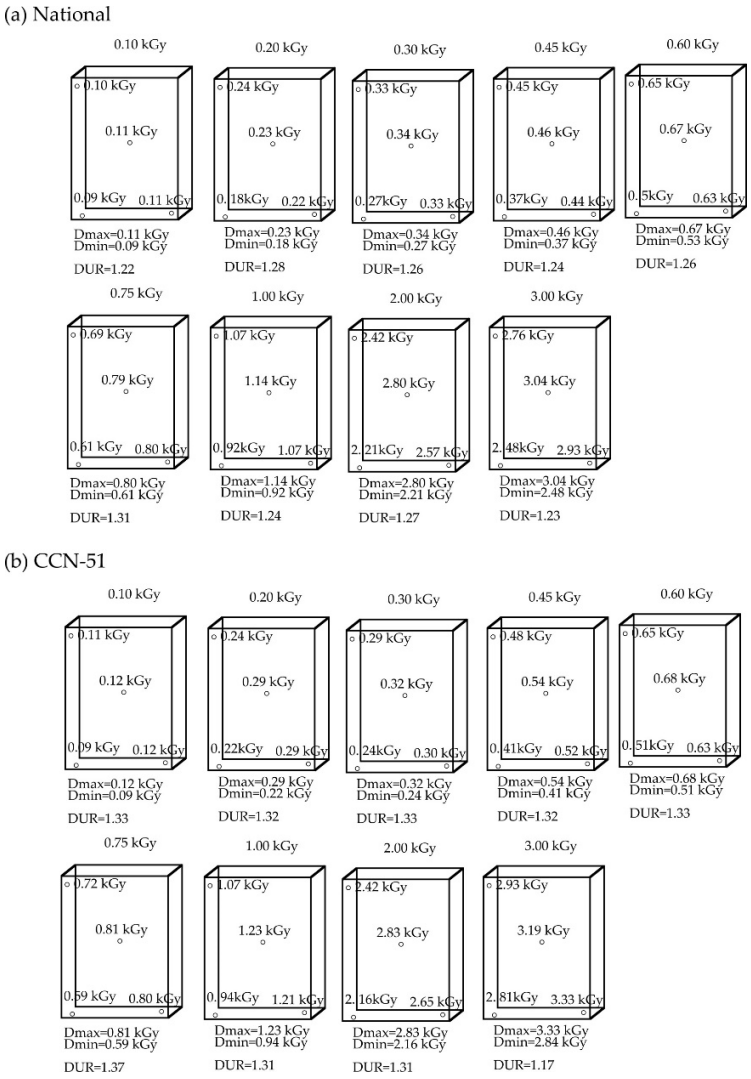


**Figure S1.** Schematic representation of the dosimeter location at four positions in the plastic trays, identification of the maximum and minimum dose and Dose Uniformity Rates (DUR) calculus at each irradiation treatment in varieties (a) National; (b) CCN-51.

The $DUR = \frac{D_{max}}{D_{min}}$ (1) was calculated by dividind the maximum dose to the minimum one.


**Figure S2.** Location of the four dosimeters at A, B, C, and D position in the plastic tray containing the cocoa beans for each treatment.

**Table S3.** Averages of the evaluated attributes in the cocoa liquor obtained from fermented and dried beans irradiated at different nominal doses for the CCN-51 and National varieties.

| Variety | Nominal Dose (kGy) | Floral | Fruity | Almond/nut | Cocoa | Acid | Bitter | Astringent | Aroma intensity |
|---|---|---|---|---|---|---|---|---|---|
| National | 0.00 | 0.00 ± 0.00 | 0.00 ± 0.00 | 1.50 ± 0.71 | 2.50 ± 0.71 | 1.00 ± 0.00 | 1.00 ± 0.00 | 1.38 ± 0.53 | 1.25 ± 0.35 |
| | 0.10 | 0.25 ± 0.35 | 0.00 ± 0.00 | 1.00 ± 1.41 | 1.50 ± 0.71 | 1.25 ± 0.35 | 1.25 ± 0.35 | 1.00 ± 1.41 | 1.00 ± 0.00 |
| | 0.20 | 0.25 ± 0.35 | 0.00 ± 0.00 | 0.88 ± 0.18 | 1.50 ± 0.71 | 1.00 ± 0.00 | 1.00 ± 0.00 | 0.50 ± 0.71 | 1.00 ± 0.00 |
| | 0.30 | 0.25 ± 0.35 | 0.00 ± 0.00 | 1.00 ± 0.00 | 1.00 ± 0.00 | 1.00 ± 0.00 | 1.00 ± 0.00 | 1.00 ± 0.00 | 1.00 ± 0.00 |
| | 0.45 | 0.00 ± 0.00 | 0.00 ± 0.00 | 1.50 ± 0.71 | 1.50 ± 0.71 | 1.00 ± 0.00 | 1.00 ± 0.00 | 0.50 ± 0.71 | 1.00 ± 0.00 |
| | 0.60 | 0.00 ± 0.00 | 0.00 ± 0.00 | 0.00 ± 0.00 | 1.75 ± 1.06 | 0.75 ± 0.35 | 1.50 ± 0.00 | 1.25 ± 0.35 | 0.50 ± 0.71 |
| | 0.75 | 0.00 ± 0.00 | 0.00 ± 0.00 | 1.25 ± 0.35 | 1.75 ± 0.35 | 1.00 ± 0.71 | 2.00 ± 0.00 | 2.13 ± 0.53 | 1.00 ± 0.00 |
| | 1.00 | 0.00 ± 0.00 | 0.00 ± 0.00 | 1.00 ± 0.00 | 1.75 ± 1.06 | 0.75 ± 0.35 | 1.25 ± 0.35 | 1.00 ± 0.00 | 1.00 ± 0.00 |
| | 2.00 | 0.00 ± 0.00 | 1.00 ± 0.00 | 0.00 ± 0.00 | 1.00 ± 0.00 | 1.00 ± 0.00 | 1.00 ± 0.00 | 1.00 ± 0.00 | 1.00 ± 0.00 |
| | 3.00 | 0.00 ± 0.00 | 1.00 ± 0.00 | 0.00 ± 0.00 | 1.00 ± 0.00 | 0.00 ± 0.00 | 1.00 ± 0.00 | 1.00 ± 0.00 | 1.00 ± 0.00 |
| CCN-51 | 0.00 | 0.00 ± 0.00 | 0.50 ± 0.71 | 1.00 ± 1.41 | 1.5 ± 0.71 | 1.50 ± 0.71 | 1.00 ± 0.00 | 1.00 ± 0.00 | 0.75 ± 0.35 |
| | 0.10 | 0.00 ± 0.00 | 0.00 ± 0.00 | 1.00 ± 0.00 | 1.00 ± 0.00 | 1.00 ± 0.00 | 1.00 ± 0.00 | 1.00 ± 0.00 | 0.50 ± 0.71 |
| | 0.20 | 0.00 ± 0.00 | 0.00 ± 0.00 | 1.00 ± 0.00 | 1.50 ± 0.71 | 2.50 ± 0.00 | 1.00 ± 0.00 | 1.00 ± 0.00 | 0.75 ± 1.06 |
| | 0.30 | 0.00 ± 0.00 | 0.00 ± 0.00 | 1.00 ± 0.00 | 1.00 ± 0.00 | 1.50 ± 0.71 | 1.00 ± 0.00 | 1.75 ± 1.06 | 0.50 ± 0.71 |
| | 0.45 | 0.00 ± 0.00 | 0.00 ± 0.00 | 1.00 ± 0.00 | 1.00 ± 0.00 | 1.50 ± 0.71 | 1.00 ± 0.00 | 2.00 ± 0.71 | 0.00 ± 0.00 |
| | 0.60 | 0.00 ± 0.00 | 0.00 ± 0.00 | 1.00 ± 0.00 | 1.00 ± 0.00 | 1.00 ± 0.00 | 1.00 ± 0.00 | 1.00 ± 0.00 | 0.50 ± 0.71 |
| | 0.75 | 0.00 ± 0.00 | 0.00 ± 0.00 | 1.00 ± 0.00 | 1.00 ± 0.00 | 1.25 ± 1.06 | 1.00 ± 0.00 | 1.00 ± 0.00 | 0.00 ± 0.00 |
| | 1.00 | 0.00 ± 0.00 | 0.00 ± 0.00 | 0.50 ± 0.00 | 0.63 ± 0.18 | 0.75 ± 0.35 | 0.50 ± 0.71 | 1.00 ± 1.41 | 0.00 ± 0.00 |
| | 2.00 | 0.00 ± 0.00 | 1.00 ± 0.00 | 0.00 ± 0.00 | 1.00 ± 0.00 | 1.00 ± 0.00 | 1.00 ± 0.00 | 1.00 ± 0.00 | 1.00 ± 0.00 |
| | 3.00 | 0.00 ± 0.00 | 1.00 ± 0.00 | 0.00 ± 0.00 | 1.00 ± 0.00 | 1.00 ± 0.00 | 1.00 ± 0.00 | 1.00 ± 0.00 | 1.00 ± 0.00 |

$\bar{x} \pm \sigma \ (n = 2)$