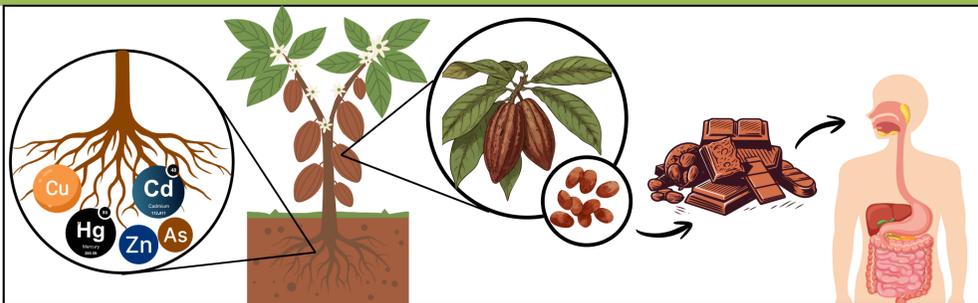


## Toxic, Essential, and Rare Earth Element Exposure from Chocolate: A Human Health Risk Assessment

Cinthyia C. Lopes<sup>1</sup>, Caroline Cristine Augusto<sup>1</sup>, Maycom Cezar Valeriano<sup>1</sup>, Monica Benicia Mamian-López<sup>1</sup>, Vera I. Slaveycova<sup>2</sup>, Bruno Lemos Batista<sup>1</sup>, Tatiana Pedron<sup>1</sup>

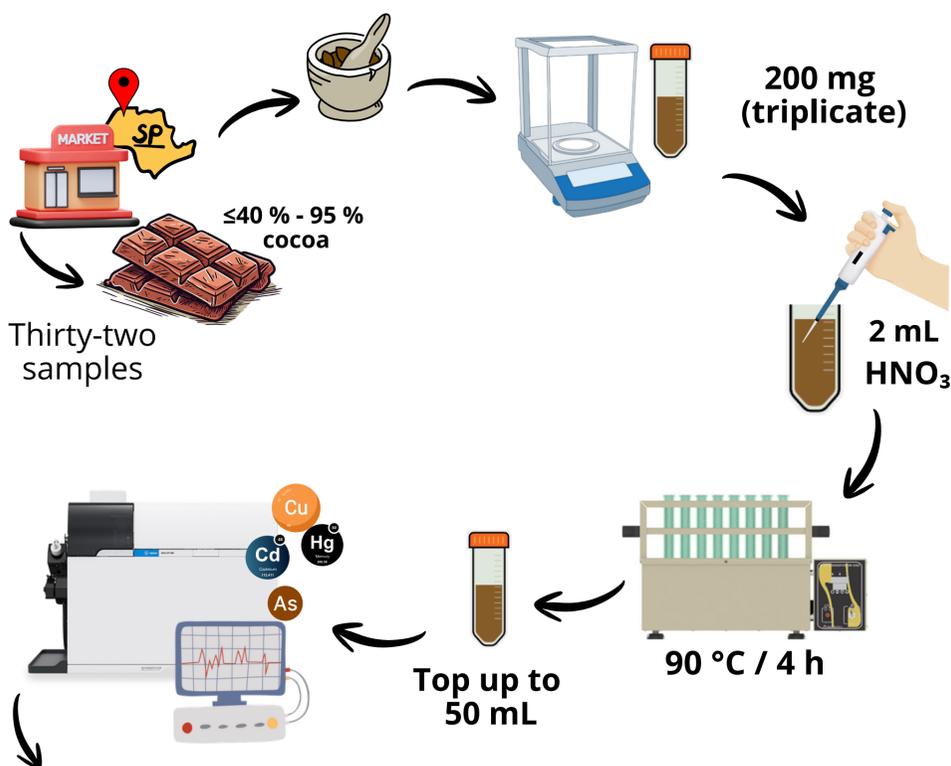
<sup>1</sup>Center for Natural and Human Sciences, Federal University of ABC  
<sup>2</sup>Forel for Environmental and Aquatic Sciences, Faculty of Sciences

### INTRODUCTION & AIM



**Aim:** To determine the concentrations of trace elements (Al, Mn, Fe, Zn, Se, As, Cd, Pb, Hg, Rb and rare earth elements) in chocolates with cocoa percentages between  $\leq 40\%$  and  $92\%$  purchased in Brazilian markets, as well as to assess the nutritional risk based on the estimated daily intake (EDI) and the target risk quotient (THQ).

### METHOD



#### • Risk assessment for the trace elements

Estimated daily intake

$$EDI = (L \times M) / BW$$

Estimation target hazard quotient.

$$THQ = \frac{E_{FR} \times E_d \times F_{IR} \times C}{RfD \times BW \times AT} \times 10^{-3}$$

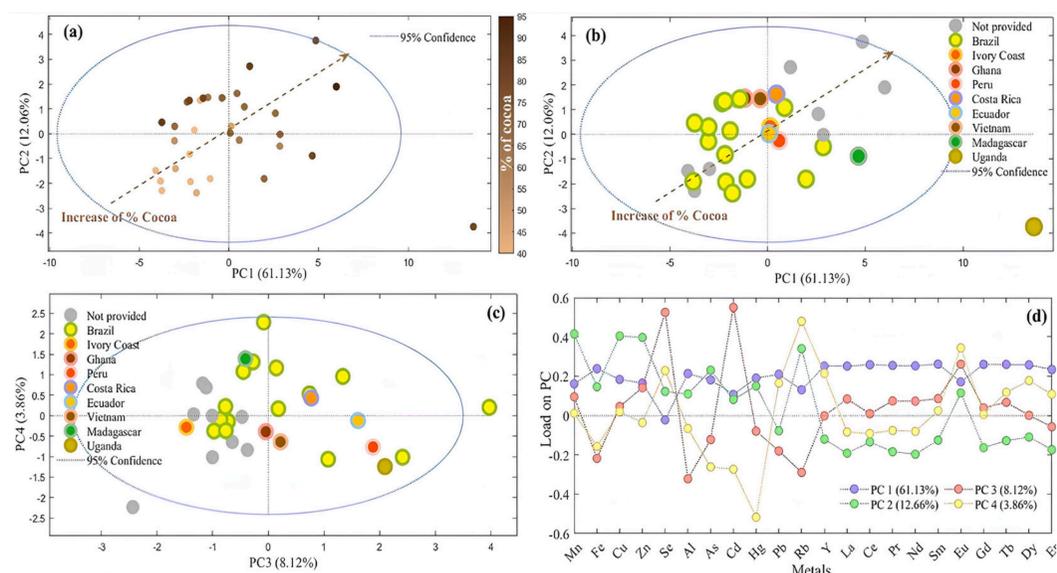
#### • Statistics

ANOVA

Principal Component Analysis (PCA)

### RESULTS & DISCUSSION

**Fig 1 - Principal Component Analysis (PCA) of chocolates.**



#### • Higher concentrations

Chocolates 80–82% cocoa

Fe: 438.23 mg kg<sup>-1</sup>  
Cd: 672.69 µg kg<sup>-1</sup>  
Ce: 114.76 µg kg<sup>-1</sup>

#### • Estimated daily intake (EDI)

Fe: 0.78 mg kg<sup>-1</sup>    Se: 0.03 mg kg<sup>-1</sup>  
Cd: 0.27 µg kg<sup>-1</sup>    Al: 0.04 mg kg<sup>-1</sup>  
Mn: 0.02 mg kg<sup>-1</sup>    Pb: 0.03 µg kg<sup>-1</sup>  
Zn: 0.15 mg kg<sup>-1</sup>

- THQ < 1 for all elements;
- Higher cocoa content = higher concentration of metals.

### CONCLUSION

- A clear relationship exists between cocoa content, element levels, and sample origin.
- There is a need to simultaneously monitor the elemental composition.

### ACKNOWLEDGMENT

This research was supported by Sao ~ Paulo Research Foundation (FAPESP, fellowships numbers: 2023/15925-1 and 2021/05186-1), National Council for Scientific and Technological Development (CNPq, grant 405087/2021-7), and Coordination for the Improvement of Higher Education Personnel Brazil – Brazil (CAPES, finance code, 001). Thanks for financial support and for granting research fellowships.