



# UNLOCKING CACAO VALUE THROUGH SENSORY EVALUATION AND DATA-DRIVEN INSIGHTS

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## Abstract

Ensuring the prosperity of cacao producers is essential for the sector's resilience and growth. By adopting best production and post-harvest practices, farmers can produce superior quality cacao with diverse flavours and achieve higher prices. However, a key challenge lies in objectively measuring cacao quality and flavours. Using standardized sensory evaluation protocols, the 2023 Cacao of Excellence Awards assessed 222 cacao samples from 52 origins. Data analysis, including k-means clustering and principal component analyses, revealed distinct flavour groups. These analyses informed the development of the "Diversity Kit," featuring 10 representative samples showcasing maximal flavour diversity for sensory training. This work highlights the potential of rigorous sensory methodologies to support farmers in producing superior quality cacao, enhance market differentiation, and foster sustainable livelihoods.

## Introduction



222 national-winning bean samples from 52 cacao origins received at Cacao R&D Lab



Quality and flavour assessed according to protocols of the **Guide for the Assessment of Cacao Quality and Flavour**<sup>1</sup>



Diversity Products developed and knowledge shared



## Materials and Methods

### Preparation and evaluation of samples

222 samples were processed following protocols of the Guide<sup>1</sup> and evaluated by the Cacao of Excellence Technical Committee. Flavour intensities were rated from 0–10 (refer to flavour wheel), alongside a global quality score.

### Improving data quality

Outliers for each attribute were removed using the the Median Absolute Deviation method<sup>2</sup> with a rejection criterion of 2.



Evaluation results of 110 cacao samples not having won a 2023 Cacao of Excellence Award with Global Quality scores > 7 and Off-flavours < 0.5 were retained for further analysis.

### Data analysis

Attribute intensity scores were standardized, and K-means clustering and Principal Component Analysis (PCA) were performed using R (RStudio, version 4.4.2). Core attributes (Cacao, Acidity, Bitterness, Astringency) and total complementary attributes (Fresh Fruit, Browning Fruit, Vegetal, Floral, Woody, Spice, Nutty, Caramel/Panela) were used to identify flavour-based sample clusters and run the PCA.

## Conclusions

These initiatives demonstrate the relevance of sensory evaluation methodologies, standards and protocols developed by Cacao of Excellence. Their widespread adoption combined with sensory evaluation training could offer value chain stakeholders, and especially producers, opportunities to better understand and enhance the quality, flavour, and market value of their cacao.

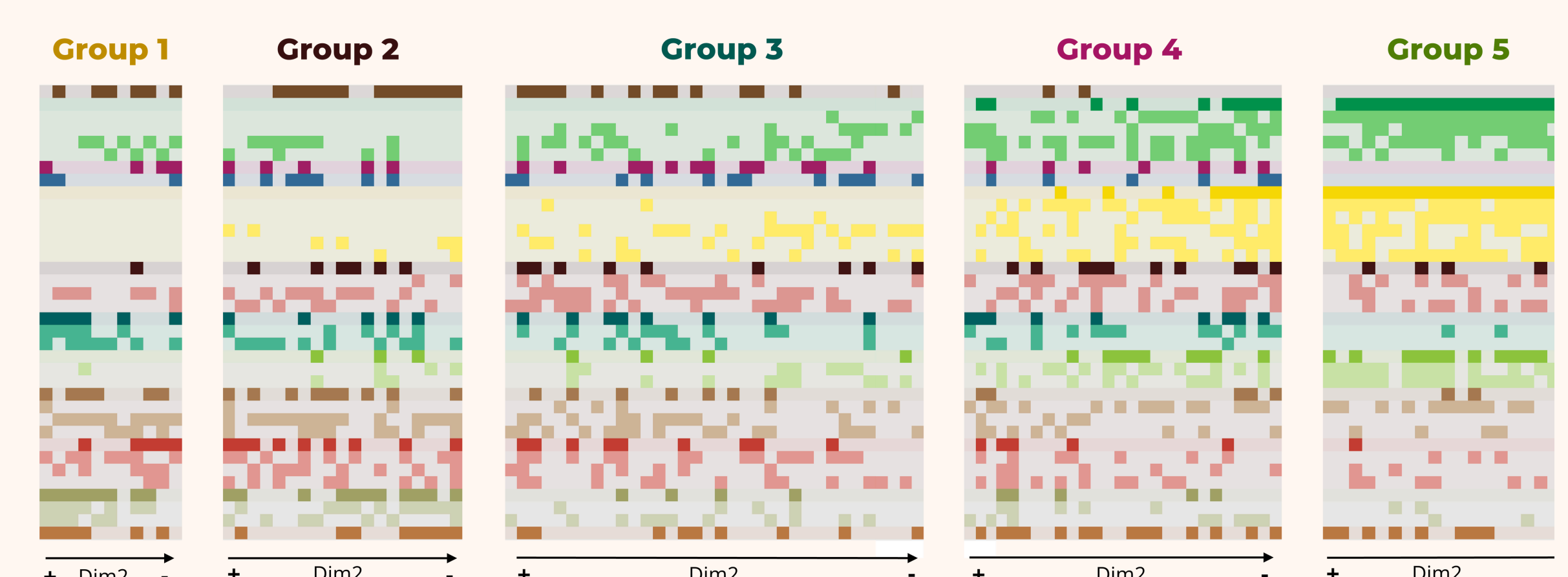
## References

- <sup>1</sup> Cacao of Excellence (2024). Guide for the Assessment of Cacao Quality and Flavour. Compiled by the Cacao of Excellence programme of the Alliance of Bioversity International and CIAT, in collaboration with the members of the Working Group on the development of the International Standards for the Assessment of Cocoa Quality and Flavour (ISCQF). Bioversity International. 216 Pages.
- <sup>2</sup> Leys, C., et al., Detecting outliers: Do not use standard deviation around the mean, use absolute deviation around the median, Journal of Experimental Social Psychology (2013)

## Results

### Grouping samples based on flavour attributes

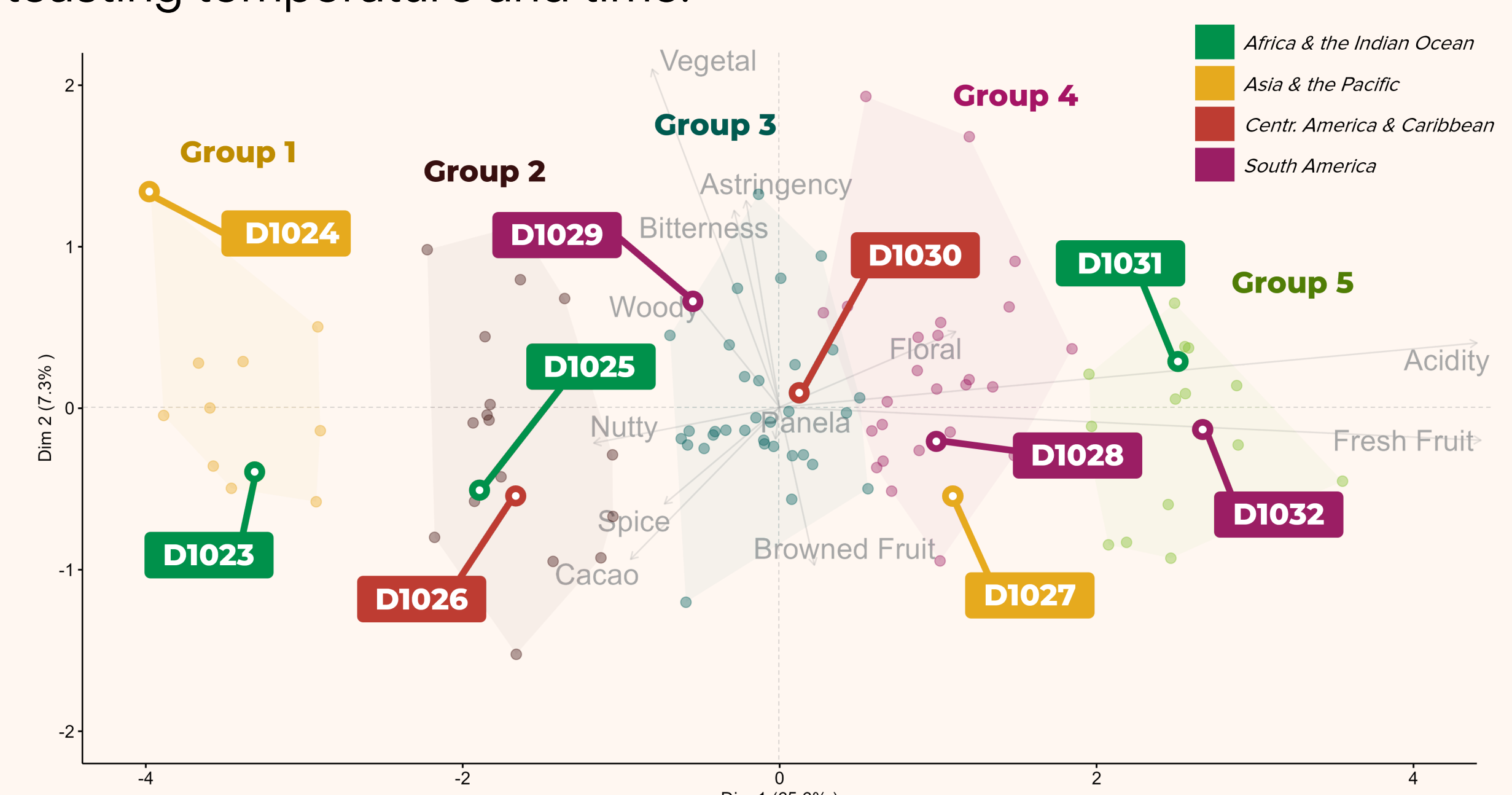
K-means clustering led to the identification of 5 groups of cacao samples, showing a progression in flavour profiles from predominantly Vegetal, Woody, Spicy, Nutty, and strong Cacao notes to increasingly Acidic, Fruity, and Floral characteristics.



Each column of this heat map represents a cacao sample, and each row corresponds to a flavour attribute (see flavour wheel for colour-attribute mapping). Filled squares indicate flavour intensity scores above 75% of all samples, highlighting key flavour traits. Samples are grouped by k-means clustering and ordered within groups by descending values of the second principal component of a PCA – see results below.

### Development of the Cacao of Excellence Diversity Kit

This analysis guided the selection of 10 cacao mass samples for the Diversity Kit, an educational and sensory training tool highlighting the diversity of flavours found in cacao. Each sample, sourced from four production regions, features contrasting flavour profiles. Accompanying data includes physical and sensory evaluation results along with key post-harvest and processing parameters such as methods and duration of fermentation and drying and toasting temperature and time.



This PCA biplot displays cacao samples grouped by k-means clusters, each represented by distinct coloured polygons. Flavour attribute vectors indicate the direction and magnitude of their influence on the principal components. Diversity Kit cacao mass samples are labelled and coloured based on their region of origin – Africa and the Indian Ocean, Asia and the Pacific, Central America and the Caribbean and South America.