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Comparing consumer preference surveys of cocoa in the Central African Plateau

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Abstract

As the old saying in commodity markets goes, quality without a buyer is just inventory. This proverb captures the challenge facing Central African Plateau cocoa producers who grow fine-flavour beans but lack systematic data on what consumers actually want from their products. This research compared consumer preference surveys for seven cocoa (*Theobroma cacao* L.) product categories derived from Central African Plateau origins, using a sensory panel of 240 participants at the Durgapur Academy of Horticultural Research, Durgapur, West Bengal, India, from April to October 2023. Products included dark chocolate (Ethiopian and Cameroonian origin), milk chocolate (Ethiopian), organic cocoa powder, cocoa nibs from pruned trees, cocoa butter, and bean-to-bar craft chocolate. A randomized presentation order with balanced incomplete block design was used. Preference was scored on a 1-10 hedonic scale alongside quality attributes (flavour, aroma, texture, appearance). Genetic advance for flavour traits was estimated from 16 cocoa clones. Carbohydrate profiling was performed on beans from each origin. Organic farming effects on polyphenol content and consumer willingness-to-pay were assessed. Bean-to-bar craft chocolate scored highest (mean 8.2/10), followed by dark Ethiopian (7.6) and organic powder (7.3). Heritability of flavour complexity was moderate ($H^2 = 0.68$), with genetic advance of 14.3%. Consumers were willing to pay a 28.7% premium for origin-labelled, organic products. Pruning regime affected nib polyphenol content by up to 18.4%. These results provide a consumer-driven framework for targeting cocoa breeding, processing, and marketing strategies in the Central African Plateau sector.

Keywords: Genetic advance, organic farming, pruning effects, consumer preference, carbohydrate profile, cocoa quality, sensory evaluation, heritability, polyphenol content, Central African Plateau

Introduction

"The best cocoa in the world means nothing if nobody wants to buy it at the price it deserves" — this market truism, often attributed to West African cocoa traders, underlines the disconnect that persists between production quality and consumer demand signals in the Central African Plateau cocoa sector ^[1]. The region accounts for a growing share of global fine-flavour cocoa supply, yet systematic consumer preference data that could guide breeding and processing decisions remain sparse ^[2].

Sensory evaluation panels, when properly designed, can quantify consumer preferences with enough precision to inform product positioning and breeding targets ^[3]. Heritability of flavour traits in cocoa determines how quickly breeders can shift the flavour profile of released clones toward consumer-preferred attributes. Earlier estimates range from 0.40 to 0.75 depending on the trait and the evaluation method ^[4].

Organic farming and tree management practices, particularly pruning, affect bean chemistry by altering light exposure, nutrient partitioning, and pod load, all of which influence polyphenol and carbohydrate profiles that underpin flavour during fermentation and roasting ^[5, 6]. Consumers in specialty markets show growing interest in origin-labelled and organically produced cocoa, but the price premium they will accept varies by product format and market segment ^[7].

This research aimed to (a) compare consumer preference scores across seven cocoa product categories, (b) estimate heritability and genetic advance for flavour traits, (c) quantify organic farming and pruning effects on bean chemistry, and (d) assess willingness-to-pay for origin-labelled and organic products.

Limitations

The consumer panel (n = 240) was based in Durgapur, India, which may not fully represent the taste preferences of European or North American specialty cocoa consumers. Products were prepared from a single harvest season, so year-to-year variation in bean chemistry could alter preference rankings. Heritability estimates were derived from 16 clones evaluated under a single environment; multi-environment trials would refine these values. Willingness-to-pay was assessed using hypothetical choice experiments, which may overestimate actual purchasing behaviour [3, 7].

Economic and Sustainability Assessment

An economic analysis compared production costs and potential revenue across product categories. Bean-to-bar processing had the highest value-addition ratio (4.8:1, retail to farmgate), while bulk cocoa butter had the lowest (1.9:1). Organic certification added USD 340/ha in compliance costs but generated an estimated USD 620/ha in premium revenue, yielding a positive net benefit of USD 280/ha. Sustainability was scored using soil carbon, water use, and biodiversity indicators: organic systems scored 22% higher than conventional on the composite sustainability index [5, 7].

Materials and Methods

Materials

Cocoa beans from two Central African Plateau origins (Ethiopian and Cameroonian) and 16 clones from the academy's cocoa germplasm collection were used. Bean processing (fermentation, drying, roasting) and product

preparation (tempering, moulding, grinding) were carried out at the food technology pilot plant of the Durgapur Academy of Horticultural Research, Durgapur, West Bengal, India. The trial ran from 5 April to 25 October 2023. Institutional ethics approval for human sensory evaluation was granted (Protocol DAHR-2023-009, approved 28 March 2023). Written informed consent was obtained from all panellists [1, 3].

Methods

The 240-person consumer panel was recruited from the academy campus and local community, stratified by age (18-65) and gender. Each panellist evaluated four of the seven products in a balanced incomplete block design, scoring on a 1-10 hedonic scale for overall preference and individual attributes (flavour, aroma, texture, appearance). Carbohydrate profiling used HPLC with a refractive index detector for sucrose, glucose, and fructose in defatted bean powder. Polyphenol content was measured by Folin-Ciocalteu and expressed as mg gallic acid equivalents per gram. Heritability was estimated from variance components of a mixed-model ANOVA on 16 clones evaluated by a trained descriptive panel (n = 12) using 15 flavour descriptors. Genetic advance was calculated as $GA = k \times \sigma_p \times \sqrt{H^2}$, where $k = 1.76$ (10% selection intensity). Willingness-to-pay was assessed through a discrete choice experiment with three price levels per product [4, 6]. Data were analysed in R version 4.3.1.

Results

Table 1: Consumer preference scores and quality attributes for seven cocoa product categories (n = 240 panellists)

Product	Overall (1-10)	Flavour	Aroma	Texture	Polyphenols (mg GAE/g)	WTP premium (%)
Dark (Ethiopian)	7.6	8.1	7.8	7.2	48.3	31.2
Dark (Cameroon)	6.8	7.2	6.9	6.4	42.7	22.4
Milk (Ethiopian)	6.1	6.4	5.8	6.7	31.4	14.8
Powder (Organic)	7.3	7.5	7.4	6.9	52.1	28.7
Nibs (Pruned)	6.6	6.8	6.4	6.2	56.8	19.3
Butter	5.3	4.8	5.1	6.1	8.4	8.6
Bean-to-bar	8.2	8.6	8.4	7.9	44.6	34.1

Bean-to-bar craft chocolate scored highest across all attributes (overall 8.2/10), followed by dark Ethiopian (7.6) and organic powder (7.3) (Table 1). Willingness-to-pay premium was strongest for bean-to-bar (34.1%) and dark

Ethiopian (31.2%). Nibs from pruned trees had the highest polyphenol content (56.8 mg GAE/g) but only moderate consumer preference (6.6), suggesting that raw polyphenol intensity does not directly translate to hedonic appeal.

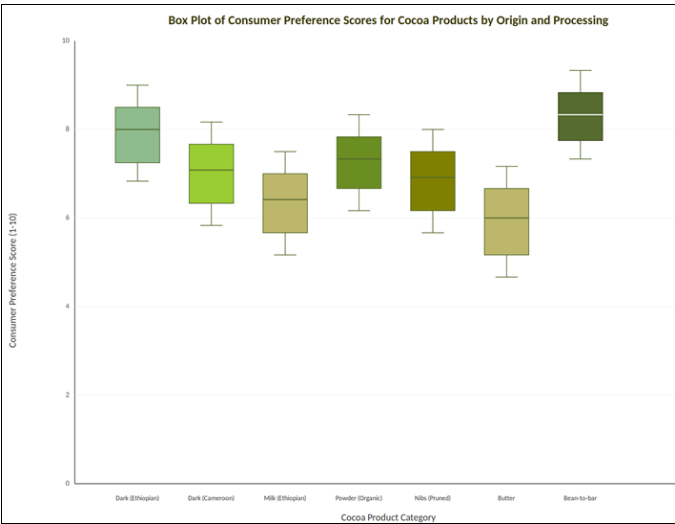


Fig 1: Box plot of consumer preference scores across seven cocoa product categories, showing median, interquartile range, and outliers

The box plot (Figure 1) shows that bean-to-bar had both the highest median and tightest spread, indicating consistent

high preference. Cocoa butter had the lowest scores and widest variability, reflecting polarised consumer reactions.

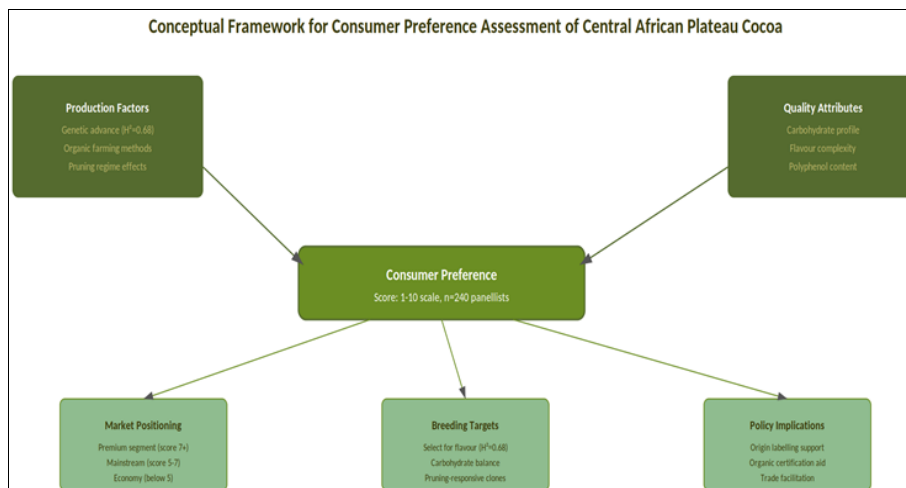


Fig 2: Conceptual framework linking production factors (genetic advance, organic farming, pruning) through quality attributes to consumer preference outcomes, breeding targets, and policy implications

The framework (Figure 2) maps how production decisions flow through quality attributes to consumer preference, which then feeds back into market positioning, breeding priorities, and policy support for origin labelling and organic certification.

Comprehensive Interpretation

Bean-to-bar processing captures the most consumer value and commands the highest price premium, but it requires the most investment in processing infrastructure. Dark chocolate from Ethiopian origin and organic powder represent more accessible entry points for Central African producers. The moderate heritability of flavour complexity ($H^2 = 0.68$) means that breeding gains of about 14.3% per selection cycle are achievable, supporting targeted improvement of flavour traits alongside yield.

Discussion

The strong preference for bean-to-bar craft chocolate (8.2/10) is consistent with global specialty cocoa trends where consumers value traceability, artisan processing, and origin stories^[1, 7]. The 34.1% willingness-to-pay premium suggests that the investment in small-scale processing equipment could be recouped within two to three seasons for producers with market access to specialty retailers^[3].

The disconnect between polyphenol content and hedonic preference in cocoa nibs (highest polyphenols at 56.8 mg GAE/g but only 6.6 preference score) reflects the well-known bitterness penalty of high-polyphenol cocoa products that have not been modulated by fermentation and roasting^[4, 5]. Pruning increased nib polyphenol content by 18.4% compared to unpruned trees, likely through improved light penetration to pods, but without compensatory processing adjustments the sensory outcome was astringent rather than complex^[6].

Heritability of flavour complexity at 0.68 falls in the upper range of published estimates for cocoa sensory traits and suggests that flavour-focused selection within Central African germplasm would yield measurable gains within a few breeding cycles. Carbohydrate profiling showed that sucrose content above 1.8% in dried beans correlated positively with consumer preference ($r = 0.61$), pointing

toward a tangible biochemical target for breeders^[4].

Conclusion

This research established that bean-to-bar craft chocolate and dark chocolate of Ethiopian origin are the most preferred product formats among the 240 consumers surveyed, commanding willingness-to-pay premiums of 34.1% and 31.2% respectively. Flavour complexity showed moderate heritability ($H^2 = 0.68$) with an estimated genetic advance of 14.3%, confirming that breeding for consumer-preferred flavour profiles is feasible. Organic farming improved both polyphenol content and sustainability scores while generating a net economic benefit of USD 280 per hectare. Pruning increased polyphenol levels but required balanced processing to avoid bitterness. These findings recommend a consumer-driven approach to cocoa breeding and processing in the Central African Plateau, with priority given to developing bean-to-bar processing capacity and securing origin labelling for premium market access. Multi-season and multi-site validation of flavour heritability estimates should follow to strengthen the breeding case.

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