National Agency for Science and Engineering Infrastructure (NASENI) Call for Proposals (2025)

Project Title:

Enhancing Nigeria cocoa flavour quality through post-harvest innovation for improved marketability and competitiveness

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Proposed Budget: ₦331,506,000

Thematic Area: Agriculture and Food Manufacturing

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Executive Summary

Cocoa is one of Nigeria's most important export crops, contributing significantly to rural livelihoods, foreign exchange, and the agro-economy. However, the competitiveness of Nigerian cocoa in the international market continues to decline, largely due to challenges in flavour quality that influence chocolate manufacturers' acceptance. The flavour attributes of cocoa are determined by complex microbial, biochemical processes influenced by post-harvest techniques, including fermentation, drying, and storage. Sub-optimal post-harvest handling by cocoa farmers often results in beans with poor quality and off-flavour, leading to inferior chocolate taste, market rejection, and reduced export value.

This project seeks to address the critical gap in Nigeria cocoa bean quality and flavour dynamics by applying the best post-harvest innovation approach capacity building for both extension agents and farmers as well as community-based hand-on technology demonstration. The outcomes will provide science-backed interventions to improve Nigerian cocoa bean quality and flavour profile, enhancing its competitiveness in the global market, and boost the income of farmers and stakeholders across the value chain.

The project is aligned with NASENI's mandate to promote research and development that strengthens Nigeria's industrial base, enhances value addition in agriculture, and drives export-oriented competitiveness. By improving cocoa flavour quality through science, technology, and innovation, this project directly contributes to Nigeria's economic diversification and industrial growth agenda.

1.0 Introduction

Cocoa (*Theobroma cacao* L.) remains one of Nigeria's most important agricultural commodities, contributing substantially to export earnings, rural livelihoods, and agro-industrial growth. Beyond economic value, cocoa occupies a central position in the global confectionery, beverage, and pharmaceutical industries. Among the various attributes that determine market acceptance, flavour quality is paramount, as it directly influences consumer preference and pricing (Esan *et al.*, 2025).

The global cocoa-chocolate sector is undergoing a significant transformation, with increasing demand for fine-flavour cocoa varieties used in premium chocolates. These are highly valued for their distinct taste and aroma profiles, shaped by genetic, environmental, and post-harvest processes. However, Nigerian cocoa, despite its high production volume, is often perceived as lacking consistent flavour quality, reducing its competitiveness against beans from Ghana, Côte d'Ivoire, Ecuador, and Peru (Santander *et al.*, 2021; Gockowski, *et al.*, 2011).
Research has shown that flavour development is a multi-factorial process involving:

i. genetic predisposition of cocoa varieties to produce quality and flavour precursors;

ii. harvest and post-harvest practices (fermentation and drying techniques), which drive biochemical pathways of flavour expression; and

iii. environmental conditions such as soil, climate, and microbial communities influencing quality cocoa production.

Despite Nigeria's rich genetic diversity in cocoa, little has been done to systematically explore, characterize, and optimize these determinants of flavour. An ongoing research by Cocoa Research Institute of Nigeria (CRIN) scientists, assessed the relationship between soil properties/fertility and cocoa flavour profiles across multiple Nigerian cocoa farms as a pilot study. Preliminary results from the flavour analysis of collected cocoa beans samples revealed flavour quality range of 190-203, with higher soil phosphorus levels that corresponded with moderate flavour scores across the sample locations (Figure 1). This is one of the clear indicators of environmental influence on cocoa beans flavour, and which seems as an eye-opener to more research in achieving the desired consistencies in the Nigerian cocoa flavour profile (Sukha, *et al.* 2010).

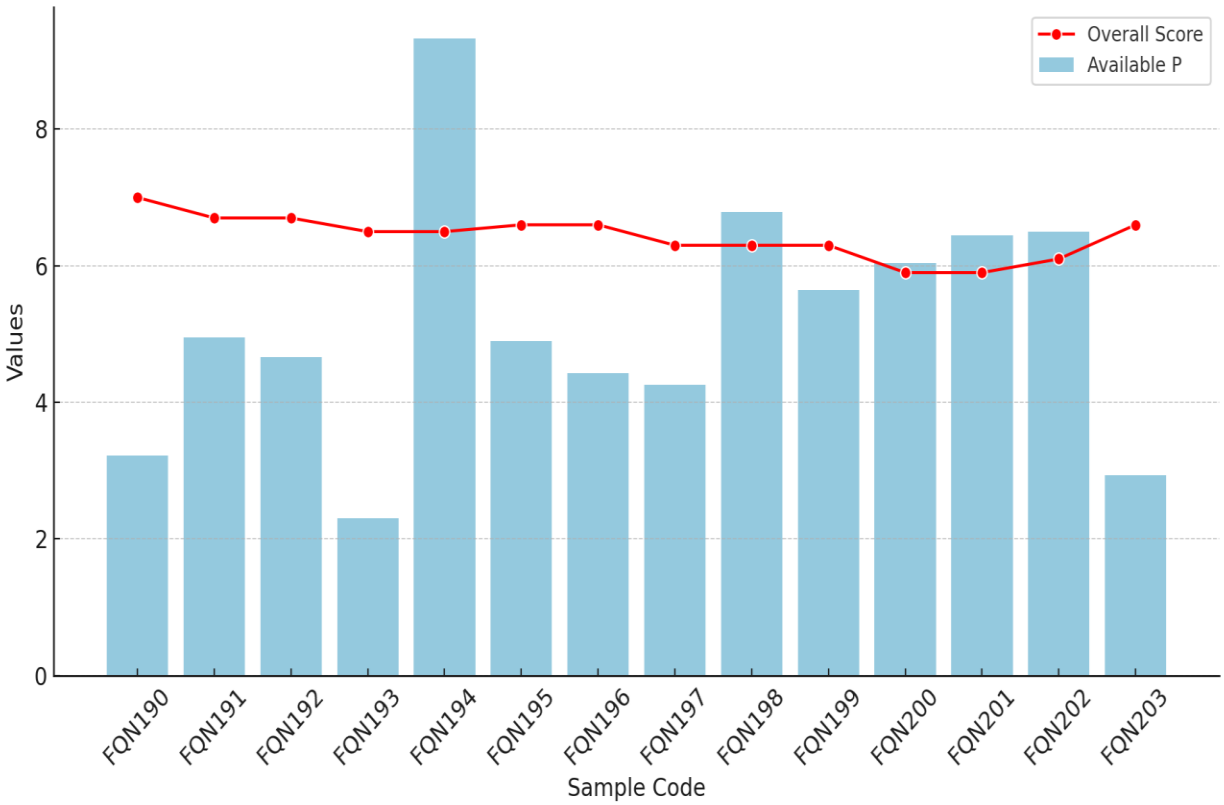

Figure 1. Available phosphorus vs overall flavour score

The National Agency for Science and Engineering Infrastructure (NASENI), with its mandate to deploy engineering and science-based innovations to accelerate Nigeria's industrialization, provides the ideal platform for developing scalable, technology-driven interventions to upgrade Nigerian cocoa's flavour profile for premium markets.

2.0 Problem Statement

Although Nigeria is among the top cocoa-producing countries globally, its beans are undervalued in the international market due to inconsistent and often substandard flavour profiles. This has resulted in:

i. lower international prices for Nigerian cocoa compared to competitor,

ii. marginalization from premium cocoa value chains; and

iii. limited capacity of smallholder farmers to benefit from the growing specialty chocolate market.

The major barriers to cocoa flavour enhancement in Nigeria include:

i. Bad harvesting practices among farmers which lead to poor quality cocoa beans production.
ii. Inadequate fermentation and drying protocols, often rudimentary and poorly standardized.
iii. Low technological adoption among smallholder farmers, leading to post-harvest quality losses.
iv. Weak research-to-industry linkages, resulting in slow commercialization of scientific innovations.

Without a deliberate intervention to address these gaps, Nigerian cocoa will continue to lose competitiveness in the global market, threatening farmer livelihoods and export revenues.

3.0 Objectives

Main Objective:

To enhance the bean quality and flavour output of Nigerian cocoa through optimized harvest and post-harvest innovations, and technology transfer for community-based application.

Specific Objectives:

1. To upscale the identification and characterization of cocoa flavor profiles associated with different ecologies in Nigeria.
2. To optimize influence behavioral change of cocoa farmers on harvesting and post-harvest practices for enhancing fine flavor and quality beans production in Nigeria
3. To design and optimize community-based fermentation and drying systems that maximize flavour precursor expression.
4. To strengthen research–industry linkages for commercialization of flavour-enhanced cocoa products.

4.0 Methodology

4.1 Upscaling Nigeria Cocoa Flavour Map Development

To establish a scientific foundation for flavour map across cocoa ecology Nigeria, ripe cocoa pods and soil samples will be collected from selected farms in all cocoa producing states in Nigeria, covering both widely cultivated and underutilized varieties. Standardized field protocols will be employed to ensure traceability of samples, with GPS mapping and farmer practice documentation. Collected samples will undergo standardized post-harvest processing (fermentation and drying) while further processing of dry bean samples and flavor analyses will be carried out in the cocoa flavor laboratory at CRIN Ibadan for the construction of a standard map for Nigeria.

4.2 Training on Best Harvesting and Post-Harvest Practices for Cocoa Quality and Flavour Optimization

Based on the available data from our previous research activities, capacity building centers will be chosen in five communities each of selected 10 cocoa producing states in Nigeria. This capacity building for farmers will be focused on best practices for pods harvesting and bean processing prior to fermentation and best technique for the optimization of bean fermentation and release of flavor precursors. Farmers participatory demonstrations approach will be adopted for pods harvesting and beans processing in each of the centers. **Fermentation Centers Development**: Bean fermentation involves series of microbial and enzyme activities leading to the release of enzyme precursors that determine the bean colour and bean flavor profiles which determine its market value and demand by chocolate and other industries. In partnership with NASENI engineers, new innovation of fermentation boxes will be designed for training of farmers cooperatives on fermentation best protocol with the development of community-based fermentation centers. In order to enhance the adoption and sustainability of these technologies, the farmers' cooperatives in each of the communities will be allowed to run the centers for the project period and beyond.

4.3 Drying and Storage Innovations

Drying is a critical step influencing the final cocoa flavour profile. Current farmer-level sun-drying methods often lead to uneven drying, mould growth, and flavour loss. This study will evaluate solar-assisted and hybrid drying systems, comparing their efficiency and impact on flavour compound preservation against traditional methods. Optimization trials will be carried out to determine the best temperature–humidity regimes that minimize off-flavours while preserving key metabolites. In partnership with NASENI engineers, affordable, portable drying units will be designed to suit smallholder farmer use, integrating features such as controlled airflow and temperature regulation. These innovations will be field-tested under diverse agro-ecological conditions to ensure scalability and adaptability.

4.4 Technology Development and Farmer Integration

To translate research outputs into practice, prototypes of low-cost, farmer-friendly fermentation and drying technologies will be fabricated using NASENI's local engineering capacities. These technologies will be tested and refined through on-farm trials in selected cocoa-producing communities. Farmer cooperatives will be trained through participatory workshops and

demonstration plots, ensuring hands-on learning and adoption of innovations. Feedback loops will be established to gather farmer experiences and challenges, which will feed back into iterative technology refinement. Extension agents will be actively engaged to provide sustained technical support to farmers.

4.5 Industry Linkages and Commercialization

Strong research–industry collaboration will be established to ensure that innovations translate into market competitiveness. Partnerships will be built with Nigerian chocolate processors and international buyers, who will participate in flavour validation exercises. A certification scheme, tentatively labelled "Nigeria Premium Flavour Cocoa", will be developed in collaboration with relevant regulatory bodies and quality assurance agencies to provide market recognition for farmers producing high-quality beans. Furthermore, targeted policy advocacy will be carried out to secure export incentives and preferential pricing mechanisms for farmers adopting improved practices. This component will also involve market promotion campaigns to position Nigerian cocoa in the premium segment of the international chocolate market.

5.0 Expected outputs:

i. Development of comprehensive Nigeria cocoa flavor map for the benefit of cocoa industry.
ii. Prototype solar/hybrid dryers and optimized drying protocols that improve quality consistency and farmer adoption.
iii. Locally fabricated, affordable post-harvest technologies adopted by farmers, alongside trained farmer groups capable of maintaining and disseminating improved practices.
iv. Industry-validated premium flavour certification scheme and policy incentives that drive adoption and enhance Nigeria's market position.

6.0 Expected Impact

i. Economic: Increased export earnings from higher-value cocoa beans (>10%).
ii. Social: Improved incomes for smallholder farmers through premium market access (> 15%).
iii. Industrial: Strengthened local processing and value addition capabilities.
iv. Strategic: Positioning Nigeria as a leader in fine-flavour cocoa research and production (Among best 3 globally).

7.0 Proposed Budget (24 Months Project) - Estimate

1. Personnel (~~₦~~60,720,000)
Principal Investigator (1) – ~~₦~~900,000/month × 24 months = ~~₦~~21,600,000
Co-Investigators (3) – ~~₦~~780,000/month × 24 months = ~~₦~~18,720,000
Research Assistants (3) – ~~₦~~500,000/month × 24 months = ~~₦~~12,000,000
Field Technicians / Extension Agents (4) – ~~₦~~350,000/month × 24 months = ~~₦~~8,400,000
Subtotal: ~~₦~~60,7200,000

2. Equipment & Infrastructure (~~₦~~40,000,000)
Portable fermentation boxes (100 units × ~~₦~~100,000) = ~~₦~~10,000,000
Solar-assisted/hybrid dryers (20 units × ~~₦~~1,000,000) = ~~₦~~20,000,000

Local engineering fabrication (NASENI workshops) = ₦10,000,000
Subtotal: ₦40,000,000

3. Farmer Training, Capacity Building & Extension (₦65,000,000)
Training workshops for farmer cooperatives (10 sessions × ₦5,000,000) = ₦50,000,000
Training manuals, IEC materials, translation into local languages – ₦5,000,000
Field demonstration plots (set-up, supervision) – ₦10,000,000
Subtotal: ₦65,000,000

5. Travel & Field Logistics (₦80,000,000)
National field trips for samples collection and flavour mapping, monitoring – ₦20,000,000
International collaboration/benchmark visits (3 trips × team of 4) – ₦10,000,000
Local transport, vehicle hire, fuel, maintenance – ₦50,000,000
Subtotal: ₦80,000,000

6. Industry Collaboration & Commercialization (₦30,000,000)
Industry roundtables, stakeholder meetings – ₦10,000,000
Flavour Laboratory activity and validation with chocolate processors – ₦15,000,000
Certification & quality assurance scheme (branding, labelling, certification body fees) – ₦5,000,000
Subtotal: ₦30,000,000

7. Dissemination & Policy Engagement (₦20,000,000)
Publications in peer-reviewed journals – ₦5,000,000
Policy briefs, advocacy workshops – ₦7,000,000
Website, media coverage, outreach – ₦8,000,000
Subtotal: ₦20,000,000

8. Monitoring, Evaluation & Reporting (₦20,000,000)
Mid-term & final evaluations – ₦10,000,000
External auditing – ₦5,000,000
Progress reporting, workshops – ₦5,000,000
Subtotal: ₦20,000,000

9. Contingency (5%) (₦15,786,000)

Grand Total: ₦331,506,000

7.0 Workplan & Timeline (24 months)

Year 1: - Baseline survey on post-harvest and upscaling of Nigeria cocoa flavor map assessment.
- Development and installation of community-based fermentation and drying trials facilities.

Year 2: - Training of extension agents and farmers on harvesting and post-harvest practices

- Farmer integration, technology dissemination, industry validation, commercialization strategies.

8.0 Summary/Conclusion

This project addresses a national priority by tackling the root causes of poor cocoa quality in Nigeria. By combining good post-harvest practices with technological innovations, it seeks to elevate Nigerian cocoa to premium status in the international market. The outcomes will strengthen Nigeria's position in the global cocoa value chain, increase farmer incomes, and promote industrialization through value addition. This aligns strongly with NASENI's mission to drive research and innovation that enhance Nigeria's economic diversification and competitiveness.

9.0 References

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