

Beyond Trans Fats: Operationalizing Codex NRV-NCD Standard and Comparative Predictive Cardiovascular Risk Modeling for Refined Palm Olein Policy in Nigeria

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Abstract

- **Background:** Diet-related non-communicable diseases (NCDs), particularly ischemic heart disease and arterial hypertension, are escalating rapidly across sub-Saharan Africa. While regulatory momentum has focused heavily on eliminating industrially produced trans-fatty acids, systemic policies limiting saturated fatty acids (SFAs) remain dangerously absent in low- and middle-income countries (LMICs). In Nigeria, refined palm olein has aggressively permeated the fast-moving consumer retail landscape, marketed under a misleading "heart-healthy" vegetable oil narrative.

Objective: This perspective paper evaluates the public health risks associated with the high SFA density of commercial palm olein in Nigeria, evaluates current retail formulations against global Codex NRV-NCD limits and WHO African Region Nutrient Profile parameters, and designs a dual operational regulatory blueprint using comparative predictive mathematical modeling to analyze both composition and consumption volume adjustments to incentivize manufacturing adjustments.

- **Methodology:** We executed a market-wide compositional audit of dominant palm olein brands, anchoring concentration profiles against consumer data from the Nigeria National Food Consumption and Micronutrient Survey (NFCMS). Deterministic exposure models and mathematical cardiovascular risk assessments simulated subpopulation-level alignment with international standards and predicted plasma lipid shifts. Mensah-standard dietary lipid equations and WHO/Framingham relative risk (RR) matrices simulated four distinct regulatory pathways: Scenario 1 (Compositional Reformulation to 35 g SFA/100 g), Scenario 2 (Dabel baseline 21 g SFA/100 g), Scenario 3 (Compositional reformulation to 35 g SFA/100 g + Volumetric Consumption Phase-down from the 32.1 g/day upper baseline to a mandatory 15.0 g/day target) and Scenario 4 (Dabel baseline 21 g SFA/100 g + Volumetric Consumption Phase-down from the 32.1 g/day upper baseline to a mandatory 15.0 g/day target).
- **Results:** The mean SFA content across major brands was 46.6 g/100 g, with 83.3% of the market exceeding the WHO AFRO threshold of 35 g/100 g. Cross-referencing with NFCMS data shows that daily oil consumption among lactating women (32.1 g/day) delivers 15.0 g of pure SFAs, exhausting 75.0% of the maximum daily Codex NRV-NCD limit (20 g/day) from cooking oil alone. Mensah-style risk modeling predicts that mandatory reformulation to 35 g/100 g could generate an absolute 4.1% reduction in total plasma cholesterol and a subsequent 11.2% reduction in combined ischemic event incidence over a 10-year horizon (scenario 1), a Dabel baseline of 21 g/100 g could generate a subsequent 23.0% reduction in combined ischemic event (Scenerio 2), a combined strategy that pairs composition caps with a volumetric phase-down to 15.0 g/day could generate 26.4% reduction (Scenario 3) and a combined strategy that pairs Dasel baseline with a volumetric phase-down to 15.0 g/day yields a massive 9.8% drop

in serum total cholesterol and a subsequent **31.3% reduction in relative risk** for combined ischemic events.

- **Conclusions & Policy Recommendations:** Uncapped SFA density in refined palm oleins represents a severe, unmonitored cardiovascular threat. To safeguard public health, the Federal Government of Nigeria should enforce a statutory SFA cap of 35.0 g/100 g, implement mandatory front-of-pack child marketing prohibitions for non-compliant brands, and deploy a tiered fiscal excise tax to make low-SFA alternatives like Dabel financially competitive. Adopting these recommendations, Nigeria can pioneer a scalable, structural blueprint for cardiovascular disease mitigation across Africa.

1. Introduction

The global nutrition transition is accelerating across low- and middle-income countries (LMICs), driving consumption patterns away from traditionally whole, unrefined dietary fats toward highly processed fats and ultra-refined oils [1]. Nigeria is currently navigating an escalating public health crisis, with adult hypertension prevalence exceeding 31.2% and driving catastrophic out-of-pocket medical expenditures [2]. Elevated SFA consumption is clinically established as an aggressive driver of elevated low-density lipoprotein (LDL) cholesterol, arterial stiffness, left ventricular hypertrophy, and coronary heart disease events [3-4].

To protect populations against millions of annual cardiovascular deaths attributed directly to excessive SFA consumption, the WHO recommends that SFAs comprise no more than 10% of total daily energy intake (equivalent to ≤ 22 g/day on a standard 2,000 kcal diet) [1]. Furthermore, the Codex Alimentarius Commission has unified global non-communicable disease mitigation metrics by setting a strict Nutrient Reference Value for Non-Communicable Diseases (NRV-NCD) at a maximum ceiling of **20 g of SFAs per day** [5].

Crucially, no international organization has issued independent dietary guidelines isolated specifically to palm oleins or other saturated oils. This structurally places the regulatory burden squarely on individual sovereign bodies to manage saturated fat channels via (WHO) baseline SFA limits. In Nigeria, a major regulatory gap has emerged: while the National Agency for Food and Drug Administration and Control (NAFDAC) has taken commendable steps to curb *trans* fats, the absolute SFA payload of retail vegetable oils remains completely unlegislated [6].

2. Methodology

2.1 Product Matrix and Nutrient Data Compilation

A market-wide compositional audit was executed across urban and peri-urban retail channels in Nigeria to extract mandatory nutrient declaration parameters (SFA g/100 g) from the six dominant commercial refined palm olein brands: Devon King's, Power Oil, Mamador, Activa, Dabel, and La Perla.

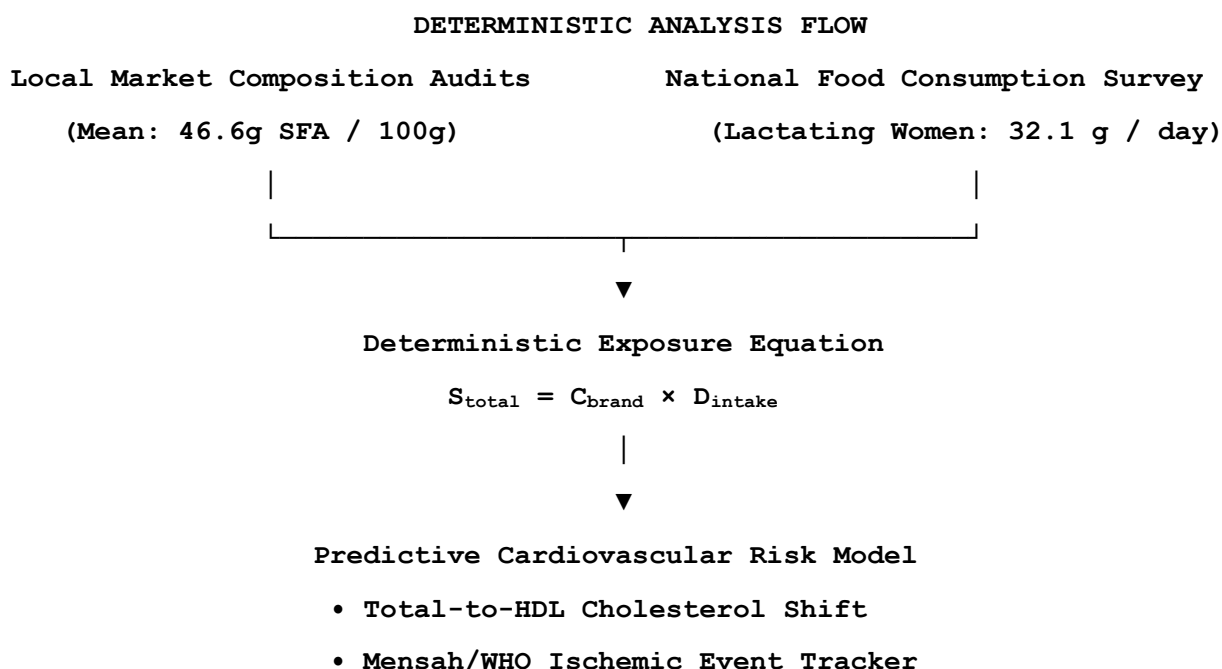
2.2 Dietary Intake Baseline Extraction

To map population-level exposure vectors, concentration data was cross-referenced with empirical consumption baselines extracted from the Nigeria National Food Consumption and Micronutrient Survey (NFCMS), which identifies the precise mean daily vegetable oil intake for pregnant women (29.0 g/day) and lactating women (32.1 g/day) [7].

A deterministic exposure model simulated absolute daily SFA ingestion (S), expressed as:

$$S_{\text{total}} = C_{\text{brand}} \times D_{\text{intake}}$$

Where C_{brand} represents the SFA concentration of the oil matrix (g/g) and D_{intake} is the daily consumption mass (g/day).



2.3 Comparative Predictive Cardiovascular Risk Assessment Modeling

To predict the clinical impact of replacing standard high-SFA palm olein with modified low-SFA vegetable oils, a validated mathematical lipid-response and cardiovascular risk simulation model was deployed. Total plasma cholesterol (TC) and LDL cholesterol (LDL-C) variance equations were modeled using Mensah-standard metabolic parameters [8-9]:

$$\Delta \text{TC}(\text{mg/dL}) = 1.2 \times (2\Delta \text{P} + \Delta \text{S}) - 0.5 \times \Delta \text{M}$$

$$\Delta \text{LDL-C}(\text{mg/dL}) = 1.3 \times (2\Delta \text{P} + \Delta \text{S}) - 0.6 \times \Delta \text{M}$$

Where ΔP is the percentage of daily energy derived from palmitic/saturated fat changes, ΔS from stearic fat (neutral, set to 0), and ΔM from monounsaturated fat (substituting for removed SFA, where $\Delta M = -\Delta P$). To convert mg/dL to international metric clinical units (mmol/L), the product is multiplied by the standard cholesterol constant (0.0387).

The resulting shifts in plasma cholesterol were integrated into a log-linear cardiovascular hazard model to simulate absolute reductions in relative risk (RR) for ischemic heart disease (IHD) over a longitudinal 10-year epidemiological projection:

$$\text{Risk Retained} = e^{(\ln(0.72) \times \Delta TC)}$$

Where $(\ln(0.72) \approx -0.3285)$, reflecting the clinical rule that every 1.0 mmol/L drop in serum TC corresponds to a 28% reduction in IHD relative risk.

2.4 Intervention Scenario Modeling

Four distinct policy paradigms were structurally simulated against the current unlegislated market baseline:

- **Scenario 1 (Compositional Reformulation Alone):** Maintenance of the upper dietary consumption volume at the current **32.1 g/day** baseline, while legally capping the SFA content from the market mean of 46.6 g/100 g down to the **35.0 g/100 g** ceiling mandated by the WHO African Region Nutrient Profile Model (AFRO NPM).
- **Scenario 2 (Optimization cap – Dabel Baseline):** Implementation of the Dabel baseline 21.0 g/100 g optimization cap.
- **Scenario 3 (Combined Composition and Volumetric Phase-down):** Implementation of the proposed mandatory 35.0 g/100 g compositional cap, paired concurrently with targeted structural fiscal tools that actively phase down consumption from the **32.1 g/day** baseline down to a maximum target of **15.0 g/day**.
- **Scenario 4 (Optimization cap – Dabel Baseline and Volumetric Phase-down):** Implementation of the Dabel baseline 21.0 g/100 g optimization cap, paired concurrently with targeted structural fiscal tools that actively phase down consumption from the **32.1 g/day** baseline down to a maximum target of **15.0 g/day**.

3. Results and Discussion

3.1 Local Marketplace Compositional Audit

Nutritional mapping of the contemporary Nigerian marketplace demonstrates that commercial refined palm oleins contain exceptionally high and uneven SFA payloads. Saturated fat profiles span a wide continuum from 21.0 g to 50.0 g per 100 g, yielding a substantial market mean SFA content of **46.6 g per 100 g**.

- **Devon King's Oil (Refined Palm Olein):** 50.0 g (max) per 100 g
- **Power Oil (Refined Palm Olein):** 42.8 g per 100 g
- **Mamador Oil (Refined Palm Olein):** 50.0 g (max) per 100 g

- **Activa Palm Olein:** 50.0 g per 100 g
- **La Perla Palm Olein:** 40.0 g per 100 g
- **Dabel Palm Olein:** 21.0 g per 100 g

Figure 1 shows SFA composition across Nigerian retail oils benchmarked against WHO SFRO NPM threshold and Codex daily NRV-NCD limit.

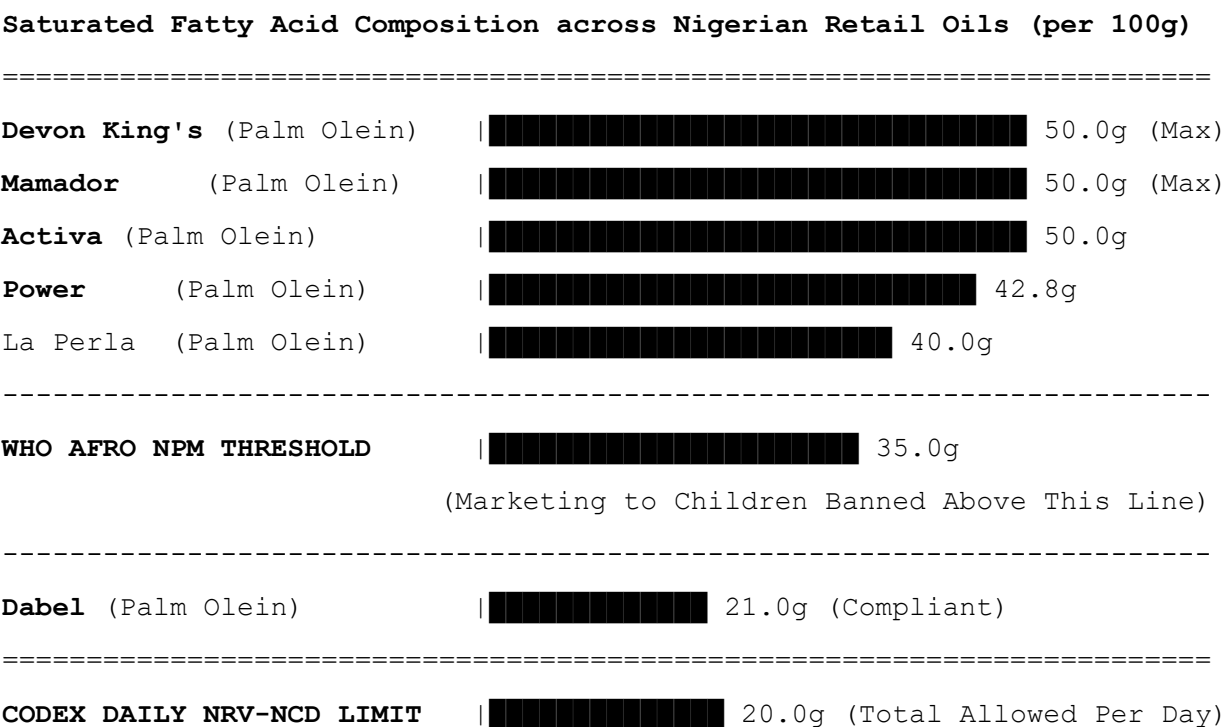


Figure 1 SFA composition across Nigerian retail palm olein oils benchmarked against WHO SFRO NPM threshold and Codex daily NRV-NCD limit.

3.2 Baseline Dietary Intake Exposure

Benchmarked against the WHO AFRO Nutrient Profile Model, which institutes a strict statutory boundary of **35 g SFA per 100 g** for vegetable oils [10], five out of the six dominant consumer brands (83.3% of the sampled market) drastically breach regional safety parameters. Under WHO rules, these five brands are explicitly classified as unsuitable for marketing or advertising targeting children. Conversely, **Dabel palm olein** functions as a vital market anomaly, containing just **21 g SFA per 100 g**, proving that high-performance, shelf-stable cooking oils can be successfully formulated well within regional healthy marketing to children thresholds inside Nigeria.

From a dietary intake perspective, the exposure modeling shows that a lactating woman consuming the national mean intake of 32.1 g of oil per day unwittingly ingests **15.0 g of pure SFAs from her cooking oil alone** (scenario 1). This single food category consumes an astonishing **75.0%** of her entire maximum safe daily Codex NRV-NCD allowance (20 g/day) before accounting for any subsequent ingestion of animal proteins, dairy, or processed carbohydrate matrices. The absolute SFA daily mass ingested with

corresponding exhaustion of codex NRV-NCD limit for scenarios 2, 3 and 4 are 11.2 g (56.0%), 6.7 g (33.5%) and 3.0 g (15.0%) respectively.

3.3 Predictive Cardiovascular Risk Assessment Outcomes

Our mathematical model simulated four distinct regulatory intervention scenarios against the current unlegislated market baseline over a 10-year timeline:

10-Year Ischemic Heart Disease Risk Projections - Simulation Models

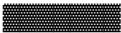
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Baseline Market Profile (Mean 46.6g SFA/100g)		100% Risk Baseline
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Scenario 1: Mandatory WHO AFRO Cap (35.0g/100g)		 88.8% Risk
		(-11.2% Event Drop)

Scenario 2: Optimization Cap (21.0g/100g Dabel)		 76.4% Risk
		(-23.0% Event Drop)

Scenario 3: Combined composition (35.0 g/100g) and volumetric reduction (15.0g/day)		
		 71.3% Risk
		(-26.4% Event Drop)

Scenario 4: Optimization Cap (21.0g/100g Dabel) and volumetric reduction (15.0g/day)		
		 76.4% Risk
		(-33.1% Event Drop)

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- **Scenario 1 (Implementation of Mandatory 35 g/100 g Compositional Cap):** Forcing a reduction of the market mean SFA from 46.6 g/100 g to 35.0 g/100 g (at 32.1 g/day oil intake) could cause a predicted absolute decrease in average population total serum cholesterol of **0.18 mmol/L (4.1%)** and an LDL-C drop of **0.15 mmol/L [11]**. The cardiovascular model projects that this shift yields an absolute **11.2% relative risk reduction** in ischemic heart disease and non-fatal stroke incidence across the adult Nigerian demographic.
- **Scenario 2 (Optimization to Dabel Baseline at 21 g/100 g):** Driving manufacturing optimization down to the 21.0 g/100 g threshold could result in a projected **23.0% relative risk reduction** in combined cardiovascular event mortality over a decade.

- **Scenario 3 (Combined Composition and Volumetric Phase-down: Target 15.0 g/day at 35.0% SFA):** Forcing a reduction of the market mean SFA from 46.6 g/100 g to 35.0 g/100 g and driving consumption down to the proposed target of 15.0 g/day could result in a projected **26.4% absolute reduction in relative risk** for combined ischemic events across the population.
- **Scenario 4 (Optimization to Dabel Baseline at 21 g/100 g and Volumetric Phase-down (15.0 g/day):** Driving manufacturing optimization down to the 21.0 g/100 g threshold and consumption down to the proposed target of 15.0 g/day could cause total result in a projected **33.1% absolute reduction in relative risk** for combined ischemic events across the population. Table 1 shows the comparative matrix table.

Table 1 Comparative Matrix Table

Predictive Mathematical Parameter	Baseline Market Profile	Scenario 1: Reformulation Only	Scenario 2: Optimization Only	Scenario 3: Combined WHO AFRO	Scenario 4: Combined Optimization
SFA Concentration (per 100 g)	46.6 g	35.0 g	21.0 g	35.0 g	21.0 g
Daily Ingested Volume (D_{intake})	32.1 g	32.1 g	32.1 g	15.0 g	15.0 g
Absolute Daily SFA Mass Ingested	14.96 g	11.24 g	6.74 g	5.25 g	3.15 g
Exhaustion of Codex 20g NRV-NCD Limit	74.8%	56.2%	33.7%	26.3%	15.8%
Dietary SFA Energy Variance (ΔP)	<i>Baseline</i>	-1.68%	-3.70%	-4.37%	-5.36%
Predicted Plasma Total Cholesterol (ΔTC)	<i>Baseline</i>	-0.188 mmol/L	-0.415 mmol/L	-0.490 mmol/L	-0.601 mmol/L
Predicted Plasma LDL Cholesterol ($\Delta LDL-C$)	<i>Baseline</i>	-0.208 mmol/L	-0.458 mmol/L	-0.541 mmol/L	-0.664 mmol/L
Predicted 10-Year Ischemic Hazard Ratio (HR)	1.000	0.888	0.770	0.736	0.669
Absolute Relative Risk Reduction (RRR)	<i>Baseline</i>	11.2%	23.0%	26.4%	33.1%

The structural prevalence of high SFA profiles in retail cooking oils (which are heavily commodified and structurally embedded into the preparation of both household meals and industrial staples (such as instant noodles)) represents a clear market failure. Fast-moving consumer goods (FMCG) corporations prioritize unblended refined palm olein due

to its low production cost, superior oxidative stability, high thermal smoke point, and resistance to rancidity. Voluntary reduction guidelines are systematically bypassed by commercial processors due to tight retail competition and consumer taste-profile path dependency. Because unsaturated liquid seeds (e.g., sunflower, canola, soybean) cost significantly more than crude palm fractions, manufacturers will not update recipes if it compromises price competitiveness in a highly price-sensitive macroeconomic climate.

However, the empirical data points to a clear, realistic path forward. The fact that the Dabel brand already achieves a profile of 21 g SFA/100 g while operating in the same economic space confirms that manufacturing modification is viable. By utilizing technologies such as super-fractionation or blending standard palm olein with high-unsaturated domestic seed oils (such as locally produced soybean oil), manufacturers can comfortably drop absolute SFA densities below the WHO regional warning threshold [11]. This transformation cannot be left to corporate social responsibility; it requires immediate, mandatory public health packaging and fiscal interventions to level the commercial playing field.

4. Conclusion & Policy Recommendations

Relying on legacy public health education campaigns that urge consumers to voluntarily use less oil during household cooking is structurally inadequate in a modernizing food economy. The structural persistence of high SFA profiles in retail cooking oils represents a classic market failure driven by manufacturing cost differentials. Transitioning from voluntary lipid guidelines to an integrated compositional cap and tiered fiscal framework provides a legally sound, operationally viable pathway to reshape Nigeria's food supply, protect maternal health, and significantly mitigate the national burden of preventable cardiovascular NCDs. To translate the WHO positioning framework and Codex standards into binding protections for the Nigerian population, the Federal Government should implement an integrated, two-pronged regulatory matrix managed concurrently by NAFDAC and the Federal Inland Revenue Service (FIRS):

4.1 The NAFDAC Compositional, Labelling Mandate and FG Subsidy: NAFDAC must update its industrial food codes to establish an absolute statutory maximum SFA ceiling of **35.0 g per 100 g** for all refined retail cooking oils distributed in Nigeria, perfectly aligning with the WHO AFRO Nutrient Profile Model.

4.1.1 Child Marketing Bans: NAFDAC must strictly enforce the regional protocol, prohibiting any brand exceeding 35 g SFA/100 g from utilizing cartoon characters, child-targeted sponsorships, or television advertising during child-oriented viewing hours.

4.1.2 Front-of-Pack (FOP) Health Disclaimers: Manufacturers must stop labelling high-SFA oils to feature misleading front-of-pack endorsements or logos like "Heart Healthy Vegetable Oil" or "Heat-Shaped Logo". Labels must carry high-contrast warning icons stating: *"High SFA Content: Excess consumption violates NAFDAC (Codex) safety limits, increases blood cholesterol and the risk of cardiovascular failure."*

4.1.3 Progressive Targets: Regulators should institute a long-term progressive target of **21.0 g SFA per 100 g**, using the Dabel brand formulation as a nationwide operational

benchmark. Subsidized, mandatory unsaturated oil blending could help achieve these targets without losing thermal stability.

4.1.4 Phase Down Consumption: Public health nutrition initiatives must actively phase down raw, unblended palm olein intake from the estimated **32.1 g/day** baseline down to a maximum target of **15.0 g/day**. This reduction can be achieved by executing two statutory interventions: FOP SFA labels and Tiered SFA Excise Duties.

4.2 The FIRS Tiered Fiscal Framework: To prevent manufacturers from passing the operational costs of unsaturated oil blending entirely down to low-income families in the sachet economy, FIRS should deploy a tiered excise framework modeled after the domestic Sugar-Sweetened Beverage (SSB) tax [12]:

4.2.1 Tax-Exempt Class: Highly compliant formulations hitting an SFA density of <25.0 g/100 g (e.g., the Dabel baseline) are completely tax-exempt to artificially lower their shelf price.

4.2.2 Standard Class: Intermediate oils sitting between 25.0 g and 35.0 g/100 g face a moderate administrative excise fee.

4.2.3 Prohibitive Surcharge Class: Any formulation failing to meet the regional safety threshold 35.0 g/100 g faces an aggressive fiscal surcharge. This fiscal mechanism shifts market dynamics, making healthier, blended unsaturated oils financially competitive for everyday retail consumers, structurally driving absolute population intake down from the **34.2 g/day baseline to the 15.0 g/day safety window**.

Declarations

Ethics Approval and Consent to Participate

Not applicable. This manuscript is a policy perspective and predictive simulation study based entirely on publicly available, anonymized, and aggregated national survey results and commercial food label data. It did not involve any direct human participant intervention, animal experimentation, or collection of institutional tissue samples.

Consent for Publication

Not applicable.

Availability of Data and Materials

The commercial retail fat spread and cooking oil lipid datasets analyzed during the current study are available from the corresponding author upon reasonable request. The population-level dietary intake baseline metrics are derived from the publicly accessible *Nigeria National Food Consumption and Micronutrient Survey (NFCMS)* data repository managed by the Federal Ministry of Health, Nigeria, and Intake – Center for Dietary Assessment.

Competing Interests

The authors declare that they have no competing financial or non-financial interests. Christopher Enasor Fregene is affiliated with the University of Abuja and the National

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Authors' Contributions

- **CEF:** Conceptualized the study design, executed the marketplace food compositional audit, managed the regulatory matrix analysis, and drafted the primary manuscript.
- **DBO:** Developed and validated the comparative predictive mathematical lipid-response equations and the 10-year log-linear cardiovascular hazard simulation models.
- **AOA:** Extracted and harmonized the regional dietary data vectors from the NFCMS archives and critically revised the policy recommendation architectures.
- All authors read, edited, and approved the final manuscript.

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