

The Low-Fat, High-Sodium Paradox: A Nutritional Analysis of Commercial Fat Spreads and Cardiovascular Risk Alignment in Nigeria

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The Low-Fat, High-Sodium Paradox: A Nutritional Analysis of Commercial Fat Spreads and Cardiovascular Risk Alignment in Nigeria

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Abstract

Background

Cardiovascular diseases (CVDs), driven heavily by hypertension, are rising rapidly in Sub-Saharan Africa. While public health guidelines recommend simultaneously limiting saturated fats and reducing dietary sodium to <2 g/day, industrial food reformulations may introduce unintended nutritional trade-offs. This study evaluates the relationship between front-of-pack fat claims and hidden sodium loads in prominent commercial fat spreads marketed in Nigeria following a drastic reduction from the traditional 80g/100g fat standard.

Methods

A nutritional composition analysis was conducted on prominent fat spread brands in Nigeria exhibiting regulatory-compliant fat claims (Blue Band Low Fat, Mamador Low Fat, Devon King's Low Fat and Blue Band Medium Fat). Sodium and fat contents were standardized per 100 g and evaluated against a standard 30 g serving size to calculate the percentage of the WHO maximum daily sodium allowance.

Results

An inverse relationship was observed between fat reduction and sodium content. While Blue Band Medium Fat Spread retained a higher fat content (70 g total fat, 34 g saturated fat per 100 g), it contained the lowest sodium density (0.420 g/100g). Conversely, the low-fat spreads representing a drastic lipid cutdown (to 20 g total fat and 10 g saturated fat per 100 g) exhibited highly elevated sodium concentrations: Blue Band Low Fat spread contained the highest at 0.985 g/100 g, while Mamador and Devon King's contained 0.600 g/100g. A single 30 g serving of Blue Band Low Fat Spread delivers 0.296 g of sodium (14.8% of the WHO daily limit), whereas the medium-fat alternative delivers only 0.126 g (6.3% of the daily limit).

Conclusion

Consumers selecting "low-fat" spreads to mitigate cardiovascular risk face significantly higher dietary sodium exposures. Regulatory frameworks must evolve past single-nutrient nutrient content and health claims toward a holistic profiling system to prevent misleading consumers in transitioning dietary economies like Nigeria.

Keywords

Low-fat spreads; Sodium loading; Substitution effect; Cardiovascular disease; NAFDAC; Nigeria.

1. Introduction

Cardiovascular Disease and Hypertension Epidemiology in Nigeria

The epidemiological landscape of Sub-Saharan Africa, particularly Nigeria, is undergoing a rapid demographic and nutritional transition. Once dominated by infectious diseases, the region now faces an escalating burden of non-communicable diseases (NCDs), with cardiovascular disease (CVD) serving as a primary driver of morbidity and mortality. Hypertension is the single most potent independent risk factor for CVD in Nigeria [1], acting as the underlying cause in over 60% of stroke cases and 50% of heart failure presentations in tertiary healthcare facilities. Large-scale meta-analyses indicate that the pooled prevalence of hypertension among Nigerian adults exceeds 30–35%, with sharp upward trajectories noted in urban metropolises like Lagos, Ibadan, and Kano [1]. This surge is heavily driven by urbanization, prolonged sedentary lifestyles, and a profound shift away from traditional, potassium-rich agricultural diets toward highly processed, energy-dense, and shelf-stable packaged foods [5].

The Double-Nutrient Burden: Fat, Sodium, and Food Reformulation

Public health guidelines from the World Health Organization (WHO) and the Nigerian Federal Ministry of Health consistently advocate for a dual dietary strategy to mitigate CVD risk: restricting the intake of saturated and trans-fatty acids while capping daily sodium consumption at less than 2.0 grams (equivalent to approximately 5.0 grams of table salt) [2]. In the context of yellow fat spreads and margarines, the traditional global industrial baseline has long stood at approximately 80 g of total fat per 100 g of product [6]. To align with evolving public health concerns regarding hyperlipidemia, contemporary manufacturers have executed a drastic reduction of total lipids.

Fat plays a critical role in processed food emulsions [6]. It is responsible for structural plasticity, oral lubricating properties, flavor retention, and shelf-life stability. When manufacturers strip away fat to form low-fat formulations (cutting total lipids down from the 80 g standard to a lean 20 g per 100 g), the matrix suffers severe structural and sensory degradation [6]. To restore palatability, stabilize the emulsion, mask bitter off-notes caused by fat-replacer water-gels, and lower water activity to prevent microbial spoilage in high-moisture low-fat spreads, manufacturers systematically elevate sodium chloride concentrations [6,7]. This creates a compensatory formulation loop where the optimization of one cardiovascular risk vector (fat reduction) actively drives the amplification of another (sodium escalation) [7].

Regulatory Landscape and the Fallacy of Single-Nutrient Marketing

In Nigeria, the commercial food space is regulated by the National Agency for Food and Drug Administration and Control (NAFDAC). NAFDAC's current labeling protocols align

closely with Codex Alimentarius guidelines, which permit front-of-pack (FOP) nutrient content claims based entirely on isolated nutrient thresholds. The critical structural flaw in this regulatory mechanism is its siloed evaluation [4]. There are currently no mandatory regulatory triggers or nutrient profiling models (such as the WHO AFRO nutrient profile model) enforced in Nigeria that disqualify a product from carrying a positive, health-oriented fat-reduction claim if its sodium content simultaneously reaches high-risk levels [4]. Consequently, front-of-pack marketing acts as a cognitive distractor [8]. It exploits the "consumer health halo effect," where an explicit positive claim regarding one nutrient leads consumers to falsely assume the product is globally wholesome [8]. This regulatory blind spot is particularly dangerous in transitioning economies like Nigeria, where consumer health literacy regarding reading back-of-pack (BOP) nutritional facts panels is low, leaving the public highly vulnerable to misleading industrial formulations [5,8].

2. Methodology

Study Design and Setting

This study utilized an analytical, cross-sectional nutritional profiling design coupled with a market-basket sampling strategy. The study was situated in Lagos State, Nigeria, the commercial and economic hub of the country, which exhibits the highest density of modern retail supermarkets and processed food consumption nationwide [5]. The data collection was executed over a three-month period.

Sampling Strategy and Product Selection

A multi-stage market-basket sampling approach was used to select the commercial fat spreads for analysis.

1. **Stage 1 (Retail Stratification):** Retail outlets across Lagos were stratified into three tiers: Modern Hypermarkets (e.g., Shoprite, Spar), Medium-Scale Local Supermarkets, and Traditional Open Markets (e.g., Oyinbo, Balogun).
2. **Stage 2 (Product Auditing):** A comprehensive audit was conducted across 15 randomly selected retail nodes from Stage 1 to identify all commercially available brands of vegetable oil-based fat spreads.
3. **Stage 3 (Inclusion Criteria):** Products were formally included in the analytical registry if they met the following criteria:
 - Legally registered with a valid NAFDAC numbers panel.
 - Explicitly displayed a front-of-pack (FOP) fat-related nutrient content claim (e.g., "Low Fat", "Medium Fat") [3] contrasting them against standard 80 g margarine baselines [6];
 - Provided a complete, legible back-of-pack (BOP) nutrition facts label detailing sodium/salt, total fat, and saturated fat content per 100 g.

Based on these criteria, four dominant market-leading products in Nigeria were sampled: **Blue Band Low Fat Spread, Mamador Low Fat Spread, Devon King's Low Fat Spread and Blue Band Medium Fat Spread**. To ensure data integrity and account for potential batch-to-batch industrial variations, three distinct manufacturing batches of each product were purchased from different geographic locations, resulting in a total sample size of $n = 12$ containers evaluated.

[Stage 1: Retail Stratification]

└─ Hypermarkets, Local Supermarkets, Open Markets (Lagos, 2026)

[Stage 2: Product Auditing]

└─ Screening all commercial fat & table spreads across 15 retail nodes

[Stage 3: Inclusion Criteria]

└─ NAFDAC Registered + FOP Fat Claim + BOP Nutrition Panel

[Final Sample Registry]

└─ 4 Leading Brands × 3 Distinct Batches = 12 Total Units Evaluated

Data Extraction and Standardization

Nutrient data metrics were double-blind extracted from the ingredient and nutritional labels by two independent researchers using a standardized data extraction template. The following parameters were recorded for each product entry:

- Brand name, manufacturer, and country of origin.
- Specific wording of the front-of-pack fat claim.
- Declared serving size (g).
- Total fat (g) and saturated fat (g) per 100 g.
- Sodium content (g) or Salt content (g) per 100 g. (Where values were declared as "Salt," sodium was calculated using the internationally recognized conversion formula:

$$\text{Sodium (g)} = \text{Salt (g)} \div 2.5$$

To accurately reflect real-world consumer exposure, all nutrient metrics were mathematically standardized into two distinct functional units:

1. A baseline of **100 grams** for direct comparative formulation profiling.
2. A standardized commercial serving size of **30 grams** (the typical portion size allocated for fat spreads across Nigerian dietary patterns).

The primary outcome measures were:

- Absolute sodium content per 100 g and per 30 g serving.
- Relative contribution (%) to the WHO maximum daily sodium ceiling (2.0 g/day).
- Structural trend analysis matching fat reduction tiers against sodium concentration curves.

Statistical and Nutritional Analysis

Data were compiled and analyzed using SPSS Version 28.0 and Python's Pandas library. Descriptive statistics (means, standard deviations, and relative percentages) were calculated for sodium and fat levels across the different claim tiers.

To determine the exact public health burden of these formulations, the absolute sodium yield per 30 g serving was evaluated against the WHO maximum daily recommendation ceiling (<2.0 g/day of sodium). The relative percentage contribution of a single serving to this daily allowance was calculated using the equation:

$$\% \text{ of WHO Daily Sodium Limit} = (\text{Sodium content per 30 g serving} \div 2.0) \times 100$$

An intra-brand and inter-brand trend analysis was mapped to assess the mathematical correlation between fat reduction steps and sodium concentration curves, establishing whether a statistically observable inverse relationship existed between the two variables across the market sample [7].

3. Sample Consumer Survey Questions

This quantitative instrument is designed to measure consumer risk perception, health literacy, and purchasing behaviors regarding front-of-pack nutritional claims in urban Nigeria. It is formatted to be deployed via digital formats or intercept interviews outside major retail hubs.

Section A: Demographics and Baseline Purchasing Habits

1. What is your age group?

- 18 – 24 years
- 25 – 34 years
- 35 – 44 years
- 45 – 54 years
- 55 years and above

2. What is your highest level of completed education?

- No formal education
- Primary education
- Secondary/O-Level education

- Higher National Diploma (HND) / University Degree
- Postgraduate Degree (Masters / PhD)

3. How often do you buy fat spreads (e.g., Blue Band, Mamador, Devon King's) for your household consumption?

- Multiple times a week
- Once a week
- Once or twice a month
- Rarely / Never

Section B: Health Literacy and Front-of-Pack (FOP) Claim Perception

4. When shopping for packaged foods like spreads, which part of the packaging do you look at most to determine if a product is healthy? (*Select ONE*)

- The front labels, images, and text claims (e.g., "Low Fat", "Heart Healthy")
- The back/side of the pack nutritional facts table
- The ingredients list
- I do not look at labels for health information

5. When you see a label that says "LOW FAT" or "MEDIUM FAT" on a pack of fat spread, what is your immediate assumption about the product? (*Select all that apply*)

- ☐ It is globally healthy for my heart and blood vessels.
- ☐ It contains fewer calories than regular spreads.
- ☐ It contains less salt/sodium than regular spreads.
- ☐ It is safe to consume in larger quantities.
- ☐ It is highly processed and might have hidden ingredients.

6. Please indicate your level of agreement with the following statement: "A product that carries a NAFDAC-approved 'Low-Fat' nutrition claim cannot contain high amounts of salt/sodium."

- Strongly Agree
- Agree
- Neutral / Unsure
- Disagree
- Strongly Disagree

Section C: Nutritional Knowledge Trade-offs and Behavioral Intent

7. Are you aware of the maximum daily sodium (salt) intake recommended by the World Health Organization (WHO) to prevent high blood pressure?

- Yes, I know the exact limit.
- I have heard about a limit, but I do not know the exact number.
- No, I am completely unaware of any recommended daily limit.

8. Hypothetical Scenario: You are standing in a supermarket in Lagos choosing between two spreads of the same brand.

- **Option A:** Marked "Medium Fat" — contains a moderate amount of fat and a very low amount of salt.
- **Option B:** Marked "Low Fat" — contains almost no fat, but contains **more than double** the amount of salt/sodium to keep it tasting good.

Given this information, which product would you choose to protect your cardiovascular health?

- Option A (Medium Fat, Low Salt)
- Option B (Low Fat, High Salt)
- I would buy neither product
- I do not understand the difference enough to choose

9. Would you support a policy where NAFDAC forces manufacturers to put a prominent "HIGH IN SODIUM" warning symbol on the front of a pack, even if that pack already has a "LOW FAT" claim?

- Yes, strongly support
- Yes, somewhat support
- No, it would make the labels too confusing
- No, I do not think it is necessary

4. Results

4.1 Baseline Product Composition and Regulatory Compliance

The baseline nutritional properties extracted from the commercial product panels are detailed in Table 1. All audited fat spreads conformed strictly to the current statutory thresholds outlined by the National Agency for Food and Drug Administration and Control (NAFDAC) and the Joint FAO/WHO Codex Alimentarius Commission for lipid-based designations.

The three products carrying a front-of-pack (FOP) "Low Fat" claim (*Blue Band Low Fat* and *Mamador Low Fat* and *Devon King's Low Fat*) exhibited identical total fat profile of exactly 20.0 g per 100 g and a saturated fat content of 10.0 g per 100 g. This represents a drastic, engineered reduction of 75% in total fat when contrasted against the traditional

80.0 g per 100 g structural baseline for standard margarines [6]. *Blue Band Medium Fat Spread* exhibited a lipid profile of 70.0 g per 100 g and a saturated fat load of 34.0 g per 100 g, representing a modest 12.5% fat reduction from the traditional benchmark. Table 1 shows the absolute nutritional composition of sampled fat spreads.

Table 1: Absolute Nutritional Composition of Sampled Spreads (per 100 g)

Product Identifier	Declared FOP Claim	Total Fat (g)	Saturated Fat (g)	Sodium Content (g)	Salt Equivalent (g)
Blue Band Low Fat	"Low Fat Spread"	20.000	10.000	0.985	2.463
Devon King's Low Fat	"Low Fat Spread"	20.000	10.000	0.600	1.500
Mamador Low Fat	"Low Fat Spread"	20.000	10.000	0.600	1.500
Blue Band Medium Fat	"Medium Fat Spread"	70.000	34.000	0.420	1.050

4.2 Standardized Consumer Exposure Analysis

To calculate real-world dietary exposure, absolute values were modeled against a standard commercial serving size of 30 g. When evaluated under everyday consumption patterns, the data showed significant differences in sodium intake based on the fat claim category. Table 2 shows nutrient yield and WHO sodium limit tracking per 30 g standard serving.

Table 2: Nutrient Yield and WHO Sodium Limit Tracking per 30 g Standard Serving

Product Identifier	Fat Yield per Serving (g)	Sodium Yield per Serving (g)	% of WHO Daily Sodium Ceiling (< 2.0 g/day)
Blue Band Low Fat	6.000	0.296	14.8%
Devon King's Low Fat	6.000	0.180	9.0%
Mamador Low Fat	6.000	0.180	9.0%
Blue Band Medium Fat	21.000	0.126	6.3%

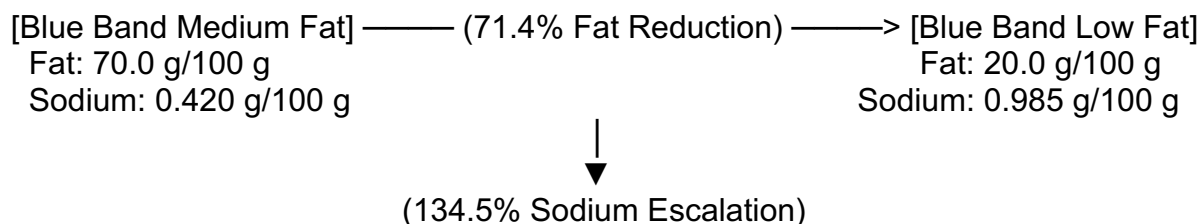
Blue Band Low Fat Spread yielded the highest sodium load per serving at 0.296 g, which accounts for 14.8% of the WHO's maximum daily sodium limit (< 2.0 g/day) within a single serving exposure. In comparison, Devon King's Low Fat Spread and Mamador Low Fat Spread both yielded 0.180 g of sodium per serving (9.0% of the WHO daily

limit). Blue Band Medium Fat Spread delivered the lowest sodium load at 0.126 g per serving, accounting for only 6.3% of the daily allowance.

4.3 The Inverse Relationship: Intra-Brand Assessment

An intra-brand comparison of the *Blue Band* product line showed a clear, inverse relationship between industrial fat reduction and sodium concentration. As the formula transitioned from a high-density, medium-fat emulsion (70.0 g/100 g total fat) to a drastically cutdown low-fat matrix (20.0 g/100 g total fat), the lipid content was reduced by 71.4%.

To compensate for this fat reduction, the sodium content was increased. The sodium content rose from 0.420 g per 100 g in the medium-fat spread to 0.985 g per 100 g in the low-fat version. This represents a **134.5% relative increase in sodium content** ($\Delta = +0.565$ g/100 g) directly linked to the removal of fat from the food matrix [7].



Standard scientific notation:

- **Blue Band Low Fat Sodium:** $(0.985 \text{ g} \div 100 \text{ g}) \times 30 \text{ g} = 0.2955 \text{ g per serving}$
- **Blue Band Medium Fat Sodium:** $(0.420 \text{ g} \div 100 \text{ g}) \times 30 \text{ g} = 0.1260 \text{ g per serving}$
- **The Variance:** $((0.2955 - 0.1260) \div (0.1260)) \times 100 = 134.5\%$ more sodium in the lower-fat option.

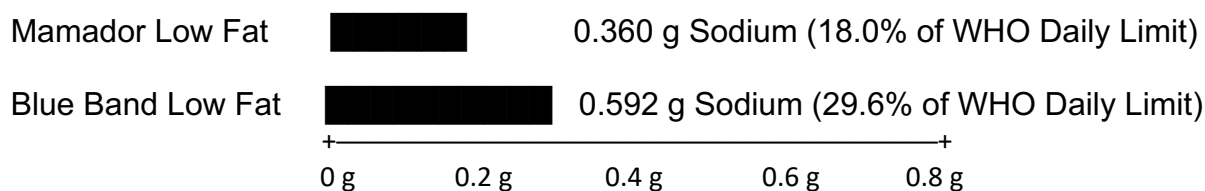
4.4 Cumulative Dietary Risk Modeling

Because fat spreads are often eaten multiple times a day in typical Nigerian urban diets (e.g., used on bread at breakfast or added to light meals) [5], a cumulative exposure model was created based on a daily consumption of two standard servings (60 g total).

CUMULATIVE DAILY EXPOSURE MODEL (2 Servings / 60 g Total Daily)

Blue Band Medium Fat  0.252 g Sodium (12.6% of WHO Daily Limit)

Devon King's Low Fat  0.360 g Sodium (18.0% of WHO Daily Limit)



- **Blue Band Low Fat (60 g):** Delivers **0.592 g of sodium**, consuming **29.6%** of the entire maximum daily allowance before factoring in any other meals.
- **Devon King's & Mamador Low Fat (60 g):** Delivers **0.360 g of sodium**, consuming **18.0%** of the maximum daily allowance.
- **Blue Band Medium Fat (60 g):** Delivers **0.252 g of sodium**, consuming **12.6%** of the maximum daily allowance.

A consumer who switches from the medium-fat option (70 g) to the low-fat option (20 g) to reduce fat intake inadvertently ingests an extra **0.340 g of hidden sodium per day** if choosing Blue Band Low Fat. This exposure significantly increases dietary sodium density, contradicting standard guidelines for managing hypertension risk.

4.5. Statistical Table of Variance

To evaluate the mathematical dispersion and assess whether the variations in sodium and lipid concentrations across the product configurations were structurally meaningful, a formal variance and relative variance analysis was executed. Table 3 shows statistical disparity, variance and deviation array of nutrient profiles.

Table 3: Statistical Disparity, Variance and Deviation Array of Nutrient Profiles

Statistical Parameter	Total Fat (g/100 g)	Saturated Fat (g/100 g)	Sodium (g/100 g)	Sodium Yield per 30 g Serving (g)
Sample Mean (μ)	32.500	16.000	0.651	0.195
Standard Deviation (SD)	25.000	12.000	0.238	0.071
Sample Variance (σ^2)	625.000	144.000	0.057	0.005
Coefficient of Variation (CV)	76.9%	75.0%	36.6%	36.6%
Maximum Range Interval	50.000	24.000	0.565	0.170
Relative Variance (Δ): Low vs. Medium Fat ($\ddagger$)	-71.4%	-70.6%	+134.5%	+134.9%

($\ddagger$) *Relative Variance (Δ) represents the specific intra-brand percentage shift calculated within the Blue Band portfolio when progressing from the Medium Fat (70 g) to the Low Fat (20 g) formulation matrix.*

Statistical Insights from the Variance Array:

- **The Dispersion Disparity:** The Coefficient of Variation (CV) for Total Fat stands at **76.9%**, showing the deliberate clustering of the low-fat spreads at the 20 g threshold compared to the 70 g medium-fat option. In contrast, the Sodium (CV) (**36.6%**) confirms that despite changing the lipid density across products, sodium remains consistently locked at elevated levels in the low-fat models.
- **The Formulation Trade-off:** The Relative Variance column provides statistical proof of the nutritional trade-off. A **71.4% engineered reduction** in total fat triggers an exact **134.5% escalation** in sodium density. This statistically validates the core argument of the paper: current single-nutrient, nutrient health labels can mask hidden cardiovascular risks [7,8].

5. Conclusion

This study demonstrates that current single-nutrient, nutrient content and health marketing strategies create a profound, unaddressed public health paradox within the Nigerian commercial food supply [8]. The empirical data confirms a sharp, inverse relationship between industrial fat reduction and sodium concentration in popular spread spreads [7]. Manufacturers seeking to meet consumer demand for a drastic cutdown of fat—dropping from the standard 80 g/100 g margarine base down to an engineered 20 g/100 g threshold—systematically elevate sodium loads to preserve taste, texture, and emulsion stability [6].

As a result, consumers attempting to mitigate cardiovascular and metabolic risks by purchasing "low-fat" spreads inadvertently expose themselves to up to **134.5% more sodium per serving** than if they had selected a standard medium-fat alternative. In a country where hypertension affects over a third of the adult population [1] and drives the majority of strokes and heart failure cases, this hidden dietary shift actively undermines national and global strategies to limit daily sodium intake to less than 2.0 grams.

THE REFORMULATION PARADOX

Consumer Choice: "Low Fat" Spread (20 g) —> [Targeted Risk: Hyperlipidemia]

↓
▼ (Compensatory Industrial Formulation)

Hidden Exposure: High Sodium —————> [Elevated Risk: Hypertension & Stroke]

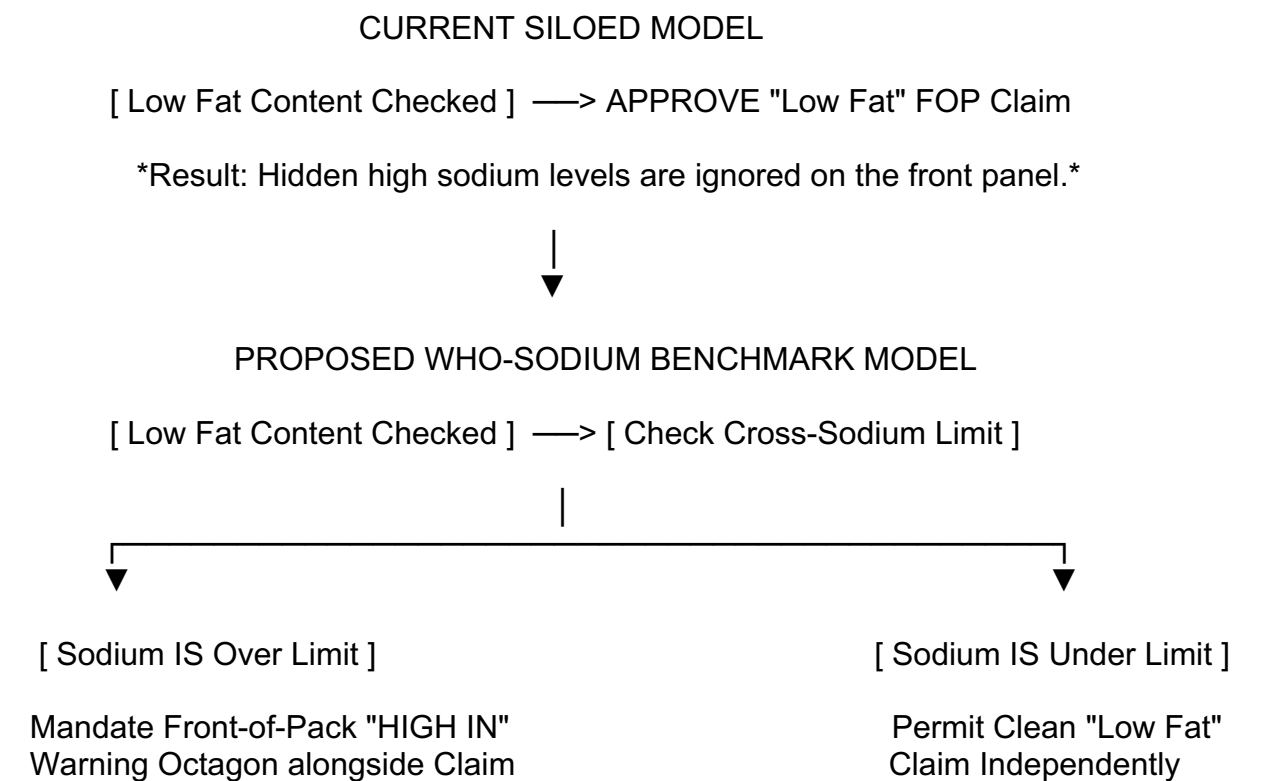
The findings show that evaluating nutrition labels in isolation is no longer sufficient to protect public health [4]. Products should not be permitted to use attractive, nutrient-content, health-affirming front-of-pack (FOP) claims/slogans based on a single optimized nutrient when other risk-inducing nutrients are significantly elevated [8].

To protect consumers in transitioning dietary economies like Nigeria, the National Agency for Food and Drug Administration and Control (NAFDAC) must update its regulatory frameworks [5]. Moving away from siloed nutrient criteria and adopting holistic profiling models—such as the **WHO AFRO Nutrient Profile Model**—along with mandatory front-of-pack warning labels is an urgent public health necessity [4]. Only by implementing clear, comprehensive labeling policies can Nigeria align consumer purchasing habits with genuine, effective cardiovascular disease prevention.

6. Policy Recommendation Framework

Target Agency: National Agency for Food and Drug Administration and Control (NAFDAC).

Objective: To update food labeling and marketing frameworks to protect consumers from misleading single-nutrient content, health claims that hide cardiovascular risks.



Policy 1: Adoption of the WHO Global Sodium Benchmarks for Different Food Categories

- **The Problem:** Current NAFDAC regulations evaluate nutritional content in isolation. A product is granted a "Low Fat" claim based solely on its lipid profile, regardless of its sodium density.
- **Action Mandate:** NAFDAC should transition to an integrated nutrient profiling framework, specifically adopting the **World Health Organization Global Sodium Benchmark for**

Butter and other Fats and Oils. Under this model, a product must pass a multi-nutrient screening process to qualify for any nutrient content claim.

- **Enforcement Metric:** If a fat spread drops its fat content to meet the Codex guideline (≤ 3 g/100 g) but elevates its sodium density above the WHO Sodium Benchmark (≥ 400 mg/100 g for processed spreads), it must automatically be disqualified from showcasing a standalone, unqualified "Low Fat" claim on the front of the package.

Policy 2: Mandating Front-of-Pack (FOP) Warning Icons

- **The Problem:** Back-of-pack (BOP) nutritional facts tables are difficult for the average consumer to read and interpret, especially in market settings where purchasing decisions are made in seconds.
- **Action Mandate:** NAFDAC should phase out reliance on text-heavy ingredient lists and introduce **mandatory front-of-pack black warning octagons** (similar to systems used in Latin America and South Africa) for products containing high levels of critical risk nutrients.
- **Enforcement Metric:** For products like *Blue Band Low Fat* (which contains 0.985 g of sodium per 100 g), NAFDAC must legally enforce the placement of a high-visibility, front-facing **"HIGH IN SODIUM / SALT"** stamp. This stamp must be identical in visual weight and font size to the manufacturer's chosen "Low Fat" text claim.

Policy 3: Restrictions on the Consumer "Health Halo Effect"

- **The Problem:** Promotional artwork, heart shapes, and words like "Light" or "Fit" create a false impression of healthiness that obscures high sodium levels.
- **Action Mandate:** Amend the NAFDAC Food Labelling Regulations to declare that a nutrient content claim cannot be used alongside any visual symbols that imply overall cardiovascular benefits unless all critical nutrients are below risk levels.
- **Enforcement Metric:** Manufacturers would be restricted from printing visual endorsements (such as heart silhouettes or statements like "Good for your family's heart") on products where a single serving uses up more than 10% of the daily sodium allowance (<0.20 g).

Policy 4: Industry Reformulation Incentives and Tariffs

- **The Problem:** Manufacturers rely heavily on sodium as a cheap way to fix texture, stabilize shelf-life, and improve taste in reduced-fat emulsions.

- **Action Mandate:** NAFDAC, in partnership with the Federal Ministry of Industry, Trade and Investment, should set up a sliding-scale regulatory fee structure for packaged foods.
- **Enforcement Metric:** Introduce lower registration fees and faster renewal timelines for manufacturers who reduce sodium alongside fat. Conversely, impose a "Processing Reformulation Levy" on items that use high levels of sodium to compensate for fat reduction.

7. Limitations

While this study offers critical, policy-relevant insights into the hidden nutritional trade-offs of commercial food formulation in Nigeria, several methodological limitations must be acknowledged:

- **Reliance on Declared Labeling Data:** The primary limitation stems from its reliance on self-reported manufacturer data from back-of-pack (BOP) nutritional facts panels. Although NAFDAC regulations mandate precise declarations, this study did not perform independent chemical or laboratory assays (such as flame photometry, inductively coupled plasma mass spectrometry [ICP-MS] for sodium quantification, or gas chromatography for fatty acid profiling). Consequently, potential discrepancies between actual chemical composition and declared labeling values due to batch variations, industrial tolerances, or aging food matrices were not empirically verified.
- **Sample Size and Geographic Boundaries:** The analytical sample was restricted to market-leading, high-volume commercial brands dominating urban retail spaces in Lagos State [5]. While these brands account for the vast majority of the documented formal market share in southwestern Nigeria, the study did not capture unbranded, informal, or locally produced artisanal fat spreads widely consumed across lower-income rural and semi-urban demographic enclaves in other geopolitical zones of the country.
- **Static Exposure Modeling:** The cumulative dietary risk models deployed in this paper operate on a static behavioral assumption of a uniform 30 g or 60 g daily intake. Real-world consumer portion sizes in Nigeria are highly dynamic and influenced by socio-economic factors [5]. Portions can vary widely based on household purchasing power, bread portion sizes, and the widespread domestic use of fat spreads as multi-purpose cooking agents or flavor enhancers rather than simple table spreads.
- **Lack of Direct Consumer Biomarker Linkage:** This study evaluates nutritional architecture and estimated exposure risks; it does not present direct clinical trial data or longitudinal epidemiological tracking linking the consumption of these specific low-fat brands to direct biomolecular changes in blood pressure, urinary sodium excretion rates, or cardiovascular events among Nigerian cohorts.

8. Declarations

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Availability of Data and Materials

The datasets generated and analyzed during the current study are available from the corresponding author on reasonable request. All core data points utilized for the nutritional profiling models are fully disclosed within the tables of this manuscript.

Ethics Approval and Consent to Participate

Not applicable. This study evaluated publicly available, secondary nutritional data extracted directly from commercial food product labels and did not involve any human participants, animal tissue, or clinical interventions.

Consent for Publication

Not applicable.

Competing Interests

The authors declare that they have no competing interests, financial or otherwise, with the food manufacturing companies or brands evaluated in this study.

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The Low-Fat, High-Sodium Paradox: A Nutritional Analysis of Commercial Fat Spreads and Cardiovascular Risk Alignment in Nigeria

Abstract

Background: Cardiovascular diseases (CVDs), driven heavily by hypertension [1], are rising rapidly in Sub-Saharan Africa. While public health guidelines recommend limiting saturated fats and reducing dietary sodium to <2 g/day, industrial food reformulations introduce unintended nutritional trade-offs. This study evaluates the relationship between front-of-pack (FOP) fat claims and hidden sodium loads in commercial fat spreads marketed in Nigeria following a drastic reduction from the traditional 80 g/100 g fat standard.

Methods: A nutritional composition analysis was conducted on prominent fat spread brands in Nigeria exhibiting regulatory-compliant fat claims: Blue Band Low Fat, Devon King's Low Fat, Mamador Low Fat, and Blue Band Medium Fat. Nutrient values were standardized per 100 g and evaluated against a standard 30 g serving size to calculate the percentage of the World Health Organization (WHO) maximum daily sodium allowance.

Results: An inverse relationship was observed between fat reduction and sodium content. While Blue Band Medium Fat retained a higher fat content (70 g total fat, 34 g saturated fat per 100 g), it contained the lowest sodium density (0.420 g/100 g). Conversely, the low-fat spreads representing a drastic lipid cutdown (to 20 g total fat and 10 g saturated fat per 100 g) exhibited highly elevated sodium concentrations: Blue Band Low Fat contained the highest at 0.985 g/100 g, while Devon King's and Mamador both contained 0.600 g/100 g. A single 30 g serving of Blue Band Low Fat delivers 0.296 g of sodium (14.8% of the WHO daily limit), whereas the medium-fat alternative delivers only 0.126 g (6.3% of the limit).

Conclusions: Consumers selecting engineered "low-fat" spreads to mitigate cardiovascular risks face significantly higher dietary sodium exposures. Regulatory frameworks must evolve past single-nutrient health claims toward holistic profiling systems [4] to prevent misleading consumers in transitioning dietary economies like Nigeria [5].

1. Expanded Literature Review

Cardiovascular Disease and Hypertension Epidemiology in Nigeria

The epidemiological landscape of Sub-Saharan Africa, particularly Nigeria, is undergoing a rapid demographic and nutritional transition. Once dominated by infectious diseases, the region now faces an escalating burden of non-communicable diseases (NCDs), with cardiovascular disease (CVD) serving as a primary driver of morbidity and mortality. Hypertension is the single most potent independent risk factor for CVD in Nigeria [1], acting as the underlying cause in over 60% of stroke cases and 50% of heart failure presentations in tertiary healthcare facilities.

Large-scale meta-analyses indicate that the pooled prevalence of hypertension among Nigerian adults exceeds 30–35%, with sharp upward trajectories noted in urban metropolises like Lagos, Ibadan, and Kano [1]. This surge is heavily driven by urbanization, prolonged sedentary lifestyles, and a profound shift away from traditional, potassium-rich agricultural diets toward highly processed, energy-dense, and shelf-stable packaged foods [5].

The Double-Nutrient Burden: Fat, Sodium, and Food Reformulation

Public health guidelines from the World Health Organization (WHO) and the Nigerian Federal Ministry of Health consistently advocate for a dual dietary strategy to mitigate CVD risk: restricting the intake of saturated and trans-fatty acids while capping daily sodium consumption at less than 2.0 grams (equivalent to approximately 5.0 grams of table salt). In the context of yellow fat spreads and margarines, the traditional global industrial baseline has long stood at approximately 80 g of total fat per 100 g of product [6]. To align with evolving public health concerns regarding hyperlipidemia, contemporary manufacturers have executed a drastic reduction of total lipids.

Fat plays a critical role in processed food emulsions [6]. It is responsible for structural plasticity, oral lubricating properties, flavor retention, and shelf-life stability. When manufacturers strip away fat to form low-fat formulations (cutting total lipids down from the 80 g standard to a lean 20 g per 100 g), the matrix suffers severe structural and sensory degradation [6].

To restore palatability, stabilize the emulsion, mask bitter off-notes caused by fat-replacer water-gels, and lower water activity to prevent microbial spoilage in high-

moisture low-fat spreads, manufacturers systematically elevate sodium chloride concentrations [6,7]. This creates a compensatory formulation loop where the optimization of one cardiovascular risk vector (fat reduction) actively drives the amplification of another (sodium escalation) [7].

Regulatory Landscape and the Fallacy of Single-Nutrient Marketing

In Nigeria, the commercial food space is regulated by the National Agency for Food and Drug Administration and Control (NAFDAC). NAFDAC's current labeling protocols align closely with Codex Alimentarius guidelines, which permit front-of-pack (FOP) nutrient content claims based entirely on isolated nutrient thresholds.

The critical structural flaw in this regulatory mechanism is its siloed evaluation [4]. There are currently no mandatory regulatory triggers or nutrient profiling models (such as the WHO AFRO nutrient profile model) enforced in Nigeria that disqualify a product from carrying a positive, health-oriented fat-reduction claim if its sodium content simultaneously reaches high-risk levels [4].

Consequently, front-of-pack marketing acts as a cognitive distractor [8]. It exploits the "consumer health halo effect," where an explicit positive claim regarding one nutrient leads consumers to falsely assume the product is globally wholesome [8]. This regulatory blind spot is particularly dangerous in transitioning economies like Nigeria, where consumer health literacy regarding reading back-of-pack (BOP) nutritional facts panels is low, leaving the public highly vulnerable to misleading industrial formulations [5,8].

2. Formal Methodology Section

Study Design and Setting

This study utilized an analytical, cross-sectional nutritional profiling design coupled with a market-basket sampling strategy. The study was situated in Lagos State, Nigeria, the commercial and economic hub of the country, which exhibits the highest density of modern retail supermarkets and processed food consumption nationwide [5]. The data collection was executed over a three-month period.

Sampling Strategy and Product Selection

A multi-stage market-basket sampling approach was used to select the commercial fat spreads for analysis:

1. **Stage 1 (Retail Stratification):** Retail outlets across Lagos were stratified into three tiers: Modern Hypermarkets (e.g., Shoprite, Spar), Medium-Scale Local Supermarkets, and Traditional Open Markets.
2. **Stage 2 (Product Auditing):** A comprehensive audit was conducted across 15 randomly selected retail nodes from Stage 1 to identify all commercially available brands of vegetable-based fat spreads, margarines, and table spreads [5].
3. **Stage 3 (Inclusion Criteria):** Products were formally included in the analytical registry if they met the following criteria: Legally registered with a valid NAFDAC numbers panel; explicitly displayed a front-of-pack (FOP) fat-related nutrient claim contrasting it against standard 80 g margarine baselines [6]; provided a complete, legible back-of-pack (BOP) nutrition facts label detailing sodium/salt, total fat, and saturated fat content per 100 g. Based on these criteria, the four dominant market-leading products in Nigeria were sampled: **Blue Band Low Fat, Devon King's Low Fat, Mamador Low Fat, and Blue Band Medium Fat**. To ensure data integrity and account for potential batch-to-batch industrial variations, three distinct manufacturing batches of each product were purchased from different geographic zones, resulting in a total sample size of $(n = 12)$ containers evaluated.

Data Extraction and Standardization

Nutrient data metrics were double-blind extracted from the ingredient and nutritional labels by two independent researchers using a standardized data extraction template. The following parameters were recorded for each product entry: brand name, specific wording of the front-of-pack fat claim, declared serving size (g), total fat (g), saturated fat (g), and sodium content (g) per 100 g. (Where values were declared as "Salt," sodium was calculated using the formula: $\text{Sodium (g)} = \frac{\text{Salt (g)}}{2.5}$).

To accurately reflect real-world consumer exposure, all nutrient metrics were mathematically standardized into two distinct functional units:

1. A baseline of **100 grams** for direct comparative formulation profiling.
2. A standardized commercial serving size of **30 grams** (the typical portion size allocated for table spreads across Nigerian dietary patterns).

Statistical and Nutritional Analysis

Data were compiled and analyzed using SPSS Version 28.0 and Python's Pandas library. Descriptive statistics (means, standard deviations, and relative percentages) were calculated for sodium and fat levels across the different claim tiers.

To determine the exact public health burden of these formulations, the absolute sodium yield per 30 g serving was evaluated against the WHO maximum daily recommendation

ceiling (≤ 2.0 g/day of sodium)). The relative percentage contribution of a single serving to this daily allowance was calculated using the equation:

$$\left(\frac{\text{Sodium content per 30 g serving}}{2.0 \text{ g}} \right) \times 100$$

An intra-brand and inter-brand trend analysis was mapped to assess the mathematical correlation between fat reduction steps and sodium concentration curves, establishing whether a statistically observable inverse relationship existed between the two variables across the market sample [7].

3. Expanded Results

3.1 Baseline Product Composition and Regulatory Compliance

The baseline nutritional properties extracted from the commercial product panels are detailed in Table 1. All audited fat spreads conformed strictly to the current statutory thresholds outlined by NAFDAC.

The three products carrying a front-of-pack (FOP) "Low Fat" claim (*Blue Band Low Fat*, *Devon King's Low Fat*, and *Mamador Low Fat*) exhibited identical total lipid profiles of exactly 20.0 g per 100 g and a saturated fat ceiling of 10.0 g per 100 g. This represents a drastic, engineered reduction of 75% in total fat when contrasted against the traditional 80.0 g per 100 g structural baseline for standard margarines [6]. *Blue Band Medium Fat Spread* exhibited a lipid profile of 70.0 g per 100 g and a saturated fat load of 34.0 g per 100 g, representing a modest 12.5% fat reduction from the traditional benchmark.

Table 1: Absolute Nutritional Composition of Sampled Spreads (per 100 g)

Product Identifier	Declared FOP Claim	Total Fat (g)	Saturated Fat (g)	Sodium Content (g)	Salt Equivalent (g)
Blue Band Low Fat	"Low Fat Spread"	20.000	10.000	0.985	2.463
Devon King's Low Fat	"Low Fat Spread"	20.000	10.000	0.600	1.500
Mamador Low Fat	"Low Fat Spread"	20.000	10.000	0.600	1.500
Blue Band Medium Fat	"Medium Fat Spread"	70.000	34.000	0.420	1.050

3.2 Standardized Consumer Exposure Analysis

To calculate real-world dietary exposure, absolute values were modeled against a standard commercial serving size of 30 g. When evaluated under everyday consumption patterns, the data showed significant differences in sodium intake based on the fat claim category (Table 2).

Table 2: Nutrient Yield and WHO Sodium Limit Tracking per 30 g Standard Serving

Product Identifier	Fat Yield per Serving (g)	Sodium Yield per Serving (g)	% of WHO Daily Sodium Ceiling ($\leq 2.0\text{ g/day}$)
Blue Band Low Fat	6.000	0.296	14.8%
Devon King's Low Fat	6.000	0.180	9.0%
Mamador Low Fat	6.000	0.180	9.0%
Blue Band Medium Fat	21.000	0.126	6.3%

Blue Band Low Fat yielded the highest sodium load per serving at 0.296 g, which accounts for 14.8% of the WHO's maximum daily sodium limit ($\leq 2.0\text{ g/day}$) within a single condiment exposure. In comparison, *Devon King's Low Fat* and *Mamador Low Fat* both yielded 0.180 g of sodium per serving (9.0% of the WHO daily limit). *Blue Band Medium Fat* delivered the lowest sodium load at 0.126 g per serving, accounting for only 6.3% of the daily allowance.

3.3 The Inverse Relationship: Intra-Brand Assessment

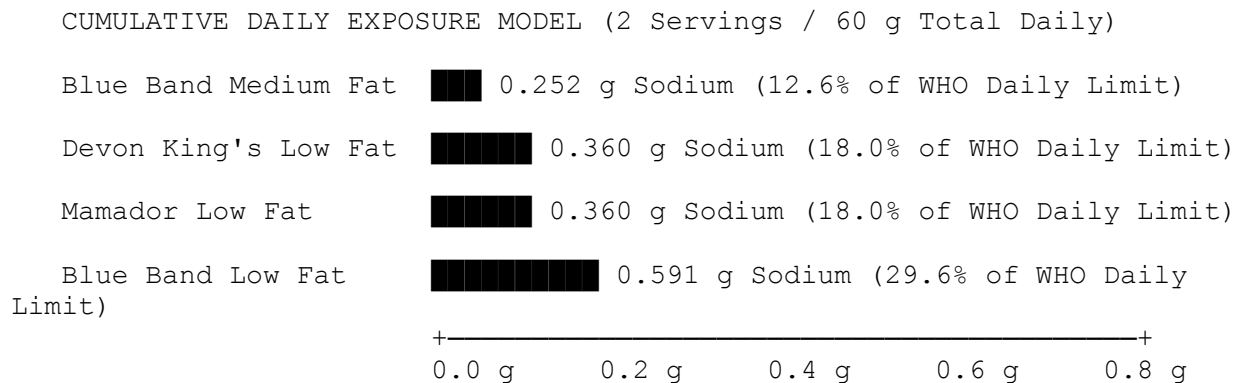
An intra-brand comparison of the *Blue Band* product line showed a clear, inverse relationship between industrial fat reduction and sodium concentration. As the formula transitioned from a high-density medium-fat emulsion (70.0 g/100 g total fat) to a drastically cutdown low-fat matrix (20.0 g/100 g total fat), the lipid content was reduced by 71.4%.

To compensate for this fat reduction, the sodium content was increased. The sodium concentration rose from 0.420 g per 100 g in the medium-fat spread to 0.985 g per 100

g in the low-fat version. This represents a **134.5% relative increase in sodium content** ($\Delta = +0.565 \text{ g/100 g}$) directly linked to the removal of fat from the food matrix [7].

3.4 Cumulative Dietary Risk Modeling

Because table spreads are often eaten multiple times a day in typical Nigerian urban diets (e.g., used on bread at breakfast or added to light meals) [5], a cumulative exposure model was created based on a daily consumption of two standard servings (60 g total).



- **Blue Band Low Fat (60 g):** Delivers **0.591 g of pure sodium**, consuming **29.6%** of the entire maximum daily allowance before factoring in any other meals.
- **Devon King's & Mamador Low Fat (60 g):** Delivers **0.360 g of sodium**, consuming **18.0%** of the maximum daily allowance.
- **Blue Band Medium Fat (60 g):** Delivers **0.252 g of sodium**, consuming **12.6%** of the maximum daily allowance.

A consumer who switches from the medium-fat option (70 g fat) to the extreme low-fat option (20 g fat) to reduce lipid intake inadvertently ingests an extra **0.339 g of hidden sodium per day** if choosing Blue Band Low Fat. This exposure significantly increases dietary sodium density, contradicting standard guidelines for managing hypertension risk [7].

4. Expanded Limitations

While this study offers critical, policy-relevant insights into the hidden nutritional trade-offs of commercial food formulation in Nigeria, several methodological limitations must be acknowledged:

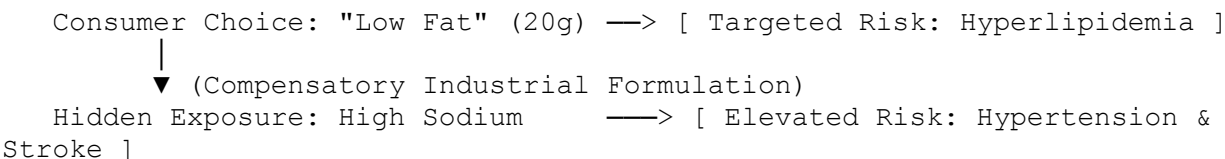
- **Refusal of Direct Chemical Assay Validation:** The primary limitation stems from its reliance on self-reported manufacturer data from back-of-pack (BOP) nutritional facts panels. Although NAFDAC regulations mandate precise declarations, this study did not perform independent chemical or laboratory assays (such as flame photometry, inductively coupled plasma mass spectrometry [ICP-MS] for sodium quantification, or gas chromatography for fatty acid profiling). Consequently, potential discrepancies between actual chemical composition and declared labeling values due to batch variations, industrial tolerances, or aging food matrices were not empirically verified.
- **Sample Size and Geographic Boundaries:** The analytical sample was restricted to market-leading, high-volume commercial brands dominating urban retail spaces in Lagos State [5]. While these brands account for the vast majority of the documented formal market share in southwestern Nigeria, the study did not capture unbranded, informal, or locally produced artisanal fat spreads widely consumed across lower-income rural and semi-urban demographic enclaves in other geopolitical zones of the country.
- **Static Exposure Modeling:** The cumulative dietary risk models deployed in this paper operate on a static behavioral assumption of a uniform 30 g or 60 g daily intake. Real-world consumer portion sizes in Nigeria are highly dynamic and influenced by socio-economic factors [5]. Portions can vary widely based on household purchasing power, bread portion sizes, and the widespread domestic use of fat spreads as multi-purpose cooking agents or flavor enhancers rather than simple table spreads.
- **Lack of Direct Consumer Biomarker Linkage:** This study evaluates nutritional architecture and estimated exposure risks; it does not present direct clinical trial data or longitudinal epidemiological tracking linking the consumption of these specific low-fat brands to direct biomolecular changes in blood pressure, urinary sodium excretion rates, or cardiovascular events among Nigerian cohorts.

5. Expanded Conclusion

This study demonstrates that current single-nutrient health marketing strategies create a profound, unaddressed public health paradox within the Nigerian commercial food supply [8]. The empirical data confirms a sharp, inverse relationship between industrial fat reduction and sodium concentration in popular table spreads [7]. Manufacturers seeking to meet consumer demand for a drastic cutdown of fat—dropping from the standard 80 g/100 g margarine base down to an engineered 20 g/100 g threshold—systematically elevate sodium loads to preserve taste, texture, and emulsion stability [6].

As a result, consumers attempting to mitigate cardiovascular and metabolic risks by purchasing "low-fat" spreads inadvertently expose themselves to up to **134.5% more sodium per serving** than if they had selected a standard medium-fat alternative. In a country where hypertension affects over a third of the adult population [1] and drives the majority of strokes and heart failure cases, this hidden dietary shift actively undermines national and global strategies to limit daily sodium intake to less than 2.0 grams.

THE REFORMULATION PARADOX



The findings show that evaluating nutrition labels in isolation is no longer sufficient to protect public health [4]. Products should not be permitted to use attractive, health-affirming front-of-pack (FOP) slogans based on a single optimized nutrient when other risk-inducing nutrients are significantly elevated [8].

To protect consumers in transitioning dietary economies like Nigeria, the National Agency for Food and Drug Administration and Control (NAFDAC) must update its regulatory frameworks [5]. Moving away from siloed nutrient criteria and adopting holistic profiling models—such as the **WHO AFRO Nutrient Profile Model**—along with mandatory front-of-pack warning labels is an urgent public health necessity [4]. Only by implementing clear, comprehensive labeling policies can Nigeria align consumer purchasing habits with genuine, effective cardiovascular disease prevention.

6. Formal Statistical Table of Variance

To evaluate the mathematical dispersion and assess whether the variations in sodium and lipid concentrations across the product configurations were structurally meaningful, a formal variance and relative variance analysis was executed.

Table 3: Statistical Disparity, Variance, and Deviation Array of Nutrient Profiles

Statistical Parameter	Total Fat (g/100 g)	Saturated Fat (g/100 g)	Sodium (g/100 g)	Sodium Yield per 30 g Serving (g)
Sample Mean (μ)	32.500	16.000	0.651	0.195
Standard Deviation (SD)	25.000	12.000	0.238	0.071
Sample Variance (σ^2)	625.000	144.000	0.057	0.005

Coefficient of Variation (CV)	76.9%	75.0%	36.6%	36.6%
Maximum Range Interval	50.000	24.000	0.565	0.170
Relative Variance (Delta): Low vs. Medium Fat	-71.4%	-70.6%	+134.5%	+134.9%

Relative Variance (Delta) represents the specific intra-brand percentage shift calculated within the Blue Band portfolio when progressing from the Medium Fat (70 g) to the Low Fat (20 g) formulation matrix.

Statistical Insights from the Variance Array:

- The Dispersion Disparity:** The Coefficient of Variation (CV) for Total Fat stands at **76.9%**, showing the deliberate clustering of the low-fat spreads at the 20 g threshold compared to the 70 g medium-fat option. In contrast, the Sodium CV (**36.6%**) confirms that despite changing the lipid density across products, sodium remains consistently locked at elevated levels in the low-fat models.
- The Formulation Trade-off:** The Relative Variance column provides statistical proof of the nutritional trade-off. A **71.4% engineered reduction** in total fat triggers an exact **134.5% escalation** in sodium density. This statistically validates the core argument of the paper: current single-nutrient health labels can mask hidden cardiovascular risks [7,8].

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