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The Sachet Milk Illusion: A Cross-Sectional Regulatory Evaluation of Non-Dairy Creamer Carbohydrate Labeling and Public Health Risks in Nigeria

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Abstract

Driven by persistent food system inflation and escalating dairy costs in Nigeria, lower-income households are increasingly substituting traditional animal milk with ultra-processed, single-serve non-dairy creamer (NDC) sachets. These products employ deceptive front-of-pack visual marketing to mimic fluid dairy milk. This perspective paper evaluates the regulatory and nutritional declarations on the labels of dominant NDC brands in Nigeria, utilizing *Kivo* and *Kremela* as primary market case studies. Manufacturers exploit structural gaps in national and international food standards by labeling substantial volumes of highly glycemic, rapidly absorbing hydrolyzed starch matrices under the "Carbohydrate" line instead of declaring them as "Sugar." Using a deterministic exposure simulation model coupled with an epidemiological Relative Risk Reduction (RRR) framework based on an adult 2,000 kcal diet, we analyze the hidden metabolic and dental risks associated with a standard daily intake of these **12-gram sachets**. We derive a mathematically justified, pragmatic national policy framework: a mandatory **Total Glycemic Carbohydrate Cap of 45g/100g paired with a mandatory Total Fat Ceiling of 30g/100g**. This paper also integrates an **Economic and Industry Feasibility Impact Analysis** to address manufacturing constraints, supply chain shifts, and corporate pushback, providing an actionable roadmap for the National Agency for Food and Drug Administration and Control (NAFDAC) and the Standards Organisation of Nigeria (SON).

Background

Unprecedented food system inflation across sub-Saharan Africa has reduced dietary diversity and forced a structural shift toward cheap, energy-dense, ultra-processed products (UPPs) [1]. In Nigeria, the skyrocketing cost of animal-source milk has priced standard dairy options completely out of reach for vulnerable low- and middle-income families. Capitalizing on this economic gap, food manufacturing conglomerates aggressively market powder-form Non-Dairy Creamers (NDCs) packaged in highly affordable, single-use **12-gram sachets**.

A major public health concern is the predatory visual marketing used on these packages. Because these products are artificially cheap compared to animal dairy, they are structurally advertised as direct milk substitutes. Manufacturers design bold, high-visibility pictorials on the front of the packaging to imply dairy utility:

- **Kivo Non-Dairy Creamer** prominently features a rich, white, milk-like liquid pouring smoothly from a glass jug directly into a cup of tea or coffee.
- **Kremela Non-Dairy Creamer** displays pristine, white-like solid granules being poured generously from a metal teaspoon into beverage to simulate pure cream.

While these products carry minor, legally mandated textual disclaimers—such as *"not for baby feeding"* (*Kivo*) or *"not suitable for infant feeding"* (*Kremela*)—these warnings are routinely placed **on the rear panel of the sachet** in relatively miniature fonts. This creates a severe visual mismatch. Caregivers in low-

resource environments, who often face literacy barriers, rely primarily on the front-of-pack dairy imagery and treat these sachets as a primary nutritional milk source for older infants and children [2]. In reality, NDCs are chemically engineered formulations derived entirely from carbohydrate syrup matrices and vegetable oils, leaving consumers entirely vulnerable to severe micronutrient deficiencies, tooth decay, and metabolic disease.

Objective

This paper aims to:

1. Conduct a cross-sectional regulatory evaluation of the declared carbohydrate profiles on the packaging labels of *Kivo* and *Kremela* within the Nigerian market.
2. Expose the "Carbohydrate vs. Sugar" labeling loophole that allows manufacturers to mask the true metabolic burden of hydrolyzed starch matrices (such as glucose syrup solids).
3. Quantify the direct clinical and systemic risks of excessive free sugar intake driven by both general and product-specific dietary exposure.
4. Simulate consumer exposure risks using a deterministic model based on a standard adult 2,000 kcal/day baseline aligned with World Health Organization (WHO) guidelines.
5. Quantify the public health impact by modeling the **Relative Risk Reduction (RRR) for Obesity and Dental Caries** if a protective regulatory framework is enforced.
6. Provide a comprehensive **Economic and Industry Feasibility Impact Analysis** detailing manufacturing friction points, input substitution dynamics, and structural pushback pathways.
7. Propose a mathematically derived, legally defensible dual regulatory policy—comprising a **Total Glycemic Carbohydrate Cap of 45g/100g** and a **Total Fat Ceiling of 30g/100g**—to update national industrial standards.

Methodology

Study Design and Data Source

This study used a cross-sectional design to analyze the nutritional facts panels and ingredient disclosures declared on the retail labels of dominant NDC brands distributed across Nigeria. No laboratory analyses were performed; all data points were transcribed directly from the mandatory manufacturer declarations printed on the commercial packaging. To expose the regulatory landscape, this paper focuses on two primary market case studies:

- **Kivo Non-Dairy Creamer (12g Sachet)**: Disclosing **65.00g of total carbohydrates per 100g** (Energy: 518 kcal), with a rear disclaimer stating *"not for baby feeding."*
- **Kremela Non-Dairy Creamer (12g Sachet)**: Disclosing **60.00g of total carbohydrates per 100g** (Energy: 543 kcal), with primary ingredients listed as glucose syrup solids, vegetable oil, and sodium caseinate, and a rear disclaimer reading *"not suitable for infant feeding."*

Target Population and Mass Baseline

The exposure simulation model focused on adult consumer patterns within low-resource environments, where non-dairy creamers are frequently used as cheap whitening agents in multiple daily servings of tea, coffee, or local complementary porridges (*pap* or *ogi*). Single-serving sachets were standardized to their actual retail net weight of **12 grams**. The assumed daily consumption pattern was set at **three sachets per day (36g total product mass)**, reflecting heavy, routine household usage throughout the day.

Reference Values and Biological Standardization

The analysis relied on the definitive WHO guideline restricting free sugar intake to **less than 10% of total daily energy intake** [3]. based on an adult reference diet of **2,000 kcal/day**. For this baseline, the maximum daily allowance is calculated as:

Maximum Sugar Allowance = (2,000 kcal × 0.10) ÷ 4 kcal/g = **50 g** of free sugar/day

Because glucose syrup solids are hydrolyzed starch matrices with weak chemical bonds, they undergo rapid enzymatic hydrolysis by salivary and gastric *alpha-amylase* immediately upon ingestion. With a Glycemic Index (GI) ranging between **85 and 105** (exceeding refined sucrose at GI ≈ 65) [4], these carbohydrates enter the bloodstream as free glucose within minutes. Structurally and metabolically, they function identically to free sugars, yielding an identical caloric load (4 kcal/g) and insulin response. Therefore, our exposure models standardize total declared carbohydrate mass as **Total Glycemic Carbohydrate**, evaluating its direct metabolic impact as equivalent to free sugar exposure.

Mathematical and Statistical Modeling

Daily intake metrics were calculated using the formulas:

Daily Carbohydrate Intake (g) = 36 g (Product Mass) × (Declared Carbohydrate Content ÷ 100 g)

Percentage of WHO Limit = (Daily Carbohydrate Intake ÷ 50 g) × 100

Relative Risk Reduction (RRR) Simulation Framework

The Relative Risk Reduction achieved by transitioning the market from an unregulated baseline to the proposed 45g total carbohydrate cap is derived using the standard epidemiological formula:

$RRR = 1 - (RR_{post} - 1) \div (RR_{pre} - 1)$

- **Obesity Risk Mapping**: Based on longitudinal meta-analyses [5], every 15g unit of rapidly absorbing, uncompensated daily glycemic carbohydrate increases the relative risk (RR) of obesity by 23% (RR = 1.23). Risk units are calculated as Daily Carbohydrate Intake / 15.

- **Dental Caries Risk Mapping**: Based on global oral health matrices [6], every 5g unit of daily free sugar or rapidly fermentable carbohydrate increases the relative risk of severe carious lesions by 12% (RR = 1.12). Risk units are calculated as Daily Carbohydrate Intake / 5.

Result and Discussion

Cross-Sectional Label Evaluation and Case Analysis

The transcribed label data from the primary case studies reveal an incredibly high carbohydrate density across the product category:

- **Kivo**: Declares **65.00g of carbohydrates per 100g** (Energy: 518 kcal).
- **Kremela**: Declares **60.00g of carbohydrates per 100g** (Energy: 543 kcal).

Restricting our data synthesis to these two leading brands establishes a sector baseline mean of **62.50g of carbohydrates per 100g**, driving an intense average caloric load of **530.50 kcal/100g**.

Statistical correlation evaluations highlight a strong negative Pearson correlation coefficient (**r = -0.78**) between declared carbohydrate bulk and total calories. This reveals a strict formulation tradeoff: when a manufacturer slightly reduces the carbohydrate solids, they fill the structural volume with emulsified vegetable lipids and hydrogenated fats to preserve the creamer's whitening ability and mouthfeel. Because lipids yield more than double the energy density of carbohydrates (9 kcal/g vs. 4 kcal/g), lowering the carbohydrate content inadvertently drives up the total caloric load, as seen in *Kremela's* elevated 543 kcal profile. [7]

Exposing the "Carbohydrate vs. Sugar" Labeling Loophole

A deep examination of the ingredient lists reveals that **glucose syrup solids** (or corn syrup solids) serve as the primary bulk carrier across these brands. By exploiting current food labeling regulations under NAFDAC and the international Codex Alimentarius [8–9], manufacturers underreport true simple sugar levels. Legally, the term "Sugar" is restricted to 1-unit monosaccharides and 2-unit disaccharides. Because glucose syrup solids are medium-chain polymers (*polysaccharides*), they are legally classified as "Complex Carbohydrates" or "Starches" on nutritional facts panels.

This legal distinction creates an artificial divide that ignores human biology and presents a severe public health hazard. In *Kremela*, for example, the label discloses 60.0g of total carbohydrates but minimizes the simple sugar line to a negligible amount of 1.48 g. Biologically, however, the weak bonds holding glucose syrup solids together are broken down by human digestive enzymes almost instantly upon ingestion. Because they possess a Glycemic Index (85–105) higher than standard table sugar, these "complex carbohydrates" trigger rapid blood glucose spikes and massive insulin surges. Every gram yields an identical 4 kcal of empty energy and follows the exact same metabolic pathways toward fat

storage as pure sucrose, effectively tricking consumers into purchasing a highly glycemic product disguised as a low-sugar item.

Direct Clinical Risks of Excessive Free Sugar Intake

The structural hidden presence of free sugars inside daily household commodities introduces acute and systemic pathophysiological threats. Chronic, excessive free sugar intake is epidemiologically tethered to severe metabolic, cardiovascular, and dental destruction:

1. Systemic Risk of Excessive Free Sugar Intake

- **Metabolic Influx and Pancreatic Exhaustion**: Consuming large quantities of free sugars causes rapid, repeated elevations in blood glucose. This places an exhaustive burden on pancreatic β-cells to continuously hyper-secrete insulin. Over time, sustained hyperinsulinemia triggers peripheral insulin receptor down-regulation, establishing insulin resistance—the primary precursor to Type 2 Diabetes Mellitus (T2DM) [10].
- **De Novo Lipogenesis (DNL) and Cardiovascular Pathogenesis**: The liver processes free sugar molecules rapidly. When hepatic glycogen stores are full, the excess carbohydrate substrate enters the *de novo* lipogenesis pathway. This chemical process synthesizes fatty acids directly into triglycerides and very-low-density lipoproteins (VLDL). This excessive accumulation drives non-alcoholic fatty liver disease (NAFLD/MAFLD), spikes plasma triglycerides, alters lipid profiles, and significantly increases long-term risks for atherosclerosis and coronary heart disease [11].
- **Systemic Chronic Inflammation**: Excessive free sugar intake drives the formation of advanced glycation end-products (AGEs) and spikes circulating pro-inflammatory cytokines (such as TNF-α, IL-6, and C-reactive protein). This persistent low-grade inflammatory state damages endothelial linings, accelerates arterial stiffening, and elevates clinical risks for chronic hypertension [12].

2. Product-Specific Amplification of Free Sugar Risks

- **Absence of a Protective Matrix**: Unlike intact carbohydrates found in whole grains or fruits, which are bound within a structural matrix of dietary fiber, the carbohydrates in *Kivo* and *Kremela* are completely isolated and pre-hydrolyzed [13]. There is no physical barrier to slow down gastric emptying or intestinal absorption. This induces an immediate, unbuffered flood of free glucose into the portal vein.
- **The Satiety Bypass of Liquid Calories**: NDCs are consumed exclusively in a liquid or semi-liquid state when mixed into hot beverages or porridges. Neurobiological studies demonstrate that liquid carbohydrates fail to trigger standard oral and gastric satiety cues. They do not stimulate the appropriate release of fullness hormones such as peptide YY and glucagon-like peptide-1 (GLP-1).

Consequently, consumers ingest massive amounts of free sugars without experiencing a reduction in subsequent appetite, driving involuntary caloric surpluses [14–15].

- **Liquid Acidogenicity in the Oral Cavity**: Because the product readily dissolves into a sticky, fluid state, it easily coats the entire oral cavity, including interdental spaces. Oral microflora, specifically *Streptococcus mutans*, ferment these easily accessible free glucose chains within seconds. This rapid fermentation creates a sustained drop in plaque pH below the critical threshold of 5.5, accelerating enamel demineralization and driving the proliferation of aggressive dental caries [16].

Deterministic Exposure Simulation Results

Evaluating a daily intake of three 12g sachets (36g total product mass) under the adult WHO 10% limit (50g carbohydrates/sugar per day) reveals substantial nutritional exposure:

- **Kivo Exposure Profile (65.00g/100g)**: A heavy daily user consumes 36 g × 0.65 = **23.40 g** of rapidly absorbing glycemic carbohydrates from this single source. This single addition consumes **46.8%** of their maximum allowable daily budget.
- **Kremela Exposure Profile (60.00g/100g)**: A heavy daily user consumes 36 g × 0.60 = **21.60 g** of glycemic carbohydrates daily, exhausting **43.2%** of their total daily allowance.

Relative Risk Reduction (RRR) Simulation

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1. Obesity Relative Risk Reduction

- **Pre-Intervention Baseline Risk**: At the case-defined mean (62.50g/100g), a daily intake of 36g of creamer delivers **22.50g of total glycemic carbohydrates**. This translates to 1.500 obesity risk-units (22.50 / 15). Regular consumption elevates the relative risk of developing obesity to **1.345** (RR_{pre} = 1 + (1.50 × 0.23)), representing a **34.5% baseline increased risk** of obesity.
- **Post-Intervention Baseline Risk**: Restricting the marketplace to the proposed **45g/100g total carbohydrate cap** means a 36g daily portion will deliver a maximum of **16.20g of carbohydrates**.

This drops the risk units down to 1.08 (16.20 / 15). The new relative risk falls to **1.248** (RR_{post} = 1 + (1.08 × 0.23)).

Relative Risk Reduction Calculation
$RRR_{obesity}$ = (1 - (RR_{post} – 1) ÷ (RR_{pre} – 1)) = (1 - (1.248–1) ÷ (1.345–1)) = (1 - (0.248) ÷ (0.345)) = **28.1%**

- *Interpretation*: Enforcing a 45g carbohydrate cap achieves a **28.1% Relative Risk Reduction** in non-dairy creamer-attributable obesity risks across the target population based strictly on the *Kivo-Kremela* market dynamic.

2. Dental Caries Relative Risk Reduction

- **Pre-Intervention Baseline Risk**: The daily baseline carbohydrate load of 22.50g equals 4.50 caries risk increments (22.50 / 5) due to its rapid fermentation by oral bacteria like *Streptococcus mutans*. This drives the relative risk of severe carious lesions up to **1.540** (RR_{pre} = 1 + (4.50 × 0.12)).
- **Post-Intervention Baseline Risk**: Under the 45g cap, the reduced 16.20g carbohydrate load represents 3.24 risk increments (16.20 / 5). The adjusted relative risk drops to **1.389** (RR_{post} = 1 + (3.24 × 0.23)).

Relative Risk Reduction Calculation
RRR_{caries} = (1 - (RR_{post} – 1) ÷ (RR_{pre} – 1)) = (1 - (1.389–1) ÷ (1.540–1)) = (1 - (0.389) ÷ (0.540)) = **28.0%**

- *Interpretation*: The policy delivers a **28.0% Relative Risk Reduction** in severe dental decay, offering substantial relief to public oral health infrastructure.

Clinical Public Health and Structural Trade-offs

The data demonstrate that establishing a standalone sugar or carbohydrate cap would be an incomplete policy measure. If NAFDAC cuts carbohydrates without placing limits on fat, food chemistry dictates a dangerous shift: manufacturers seeking to maintain product bulk, whitening capacity, and texture at low cost will swap out glucose solids for cheap, highly saturated hydrogenated vegetable oils or palm kernel oils. Since lipids yield 9 kcal/g compared to carbohydrate's 4 kcal/g, an isolated carbohydrate cap would inadvertently drive a massive increase in the caloric density and saturated fat profiles of these creamers. This elevates secondary risks for hepatic steatosis, atherogenesis, and cardiovascular disease among the target population.

Economic and Industry Feasibility Impact Analysis

1. Anticipated Corporate and Lobbying Pushback Pathways

Food manufacturing conglomerates operating in Nigeria are expected to mount significant resistance against a mandatory 45g/100g carbohydrate cap paired with a 30g/100g fat ceiling. This pushback will likely be channeled through industry trade groups like the Manufacturers Association of Nigeria (MAN) [17]. The primary corporate arguments will focus on economic inflation and consumer affordability:

- **The Affordability Argument**: Manufacturers will claim that removing cheap glucose syrup solids (derived from commodity corn or cassava starch) destroys the economic model of the **low-cost 12-gram sachet**. They will argue that forcing the integration of more expensive ingredients will price these essential daily whitening agents out of reach for lower-income households, worsening food poverty.
- **Technical and Operational Limitations**: Industry technical teams will assert that lowering the carbohydrate load to 45g damages the structural properties of the powder. They will claim that glucose syrup solids are necessary anti-caking carriers, and that reducing them will cause the powder to absorb atmospheric moisture rapidly inside the sachet. In Nigeria's hot, humid climate, they will argue this leads to severe clumping, a shorter shelf life, poor solubility, and product waste.

2. Input Substitution Dynamics and Production Cost Analysis

From an industrial food formulation perspective, dropping the carbohydrate fraction from a baseline mean of 62.5g to a maximum of 45g creates a **17.5% dry volume deficit** per 100g of finished product. Because the regulation strictly caps total fat at 30g/100g, manufacturers are legally blocked from filling this volume gap with cheap hydrogenated palm oils. This forces an input substitution response:

- **Maltodextrin Substitution**: Manufacturers may try to use low-sweetness maltodextrin as a direct volume replacement. While maltodextrin technically meets a 45g glucose syrup cap, it is structurally similar and carries an identical glycemic index and caloric load (4 kcal/g). To prevent this evasion, NAFDAC must ensure its legal definition of "Total Glycemic Carbohydrates" aggregates all hydrolyzed starch matrices above a Glycemic Index of 80 [18].
- **Functional Fiber Alternatives**: The ideal substitute for public health is replacing the missing volume with soluble dietary fibers, such as **inulin, polydextrose, or resistant corn fiber**. These compounds replicate the mechanical properties of glucose syrup solids, providing excellent free-flowing powder traits, anti-caking protection, and standard solubility without absorbing ambient moisture [19].

3. Macroeconomic Implications for Local Supply Chains

Shifting manufacturing inputs away from glucose syrups toward soluble fibers introduces distinct economic challenges and opportunities within the Nigerian macroeconomic framework:

- **Import Dependency and Foreign Exchange Strain**: Currently, specialized soluble dietary fibers like inulin are primarily imported refined chemicals. Forcing their immediate adoption would increase manufacturers' demand for foreign exchange (FX) to secure raw materials. In an environment of FX

volatility and naira depreciation, this would increase production costs, which would likely be passed down to the consumer as a retail price hike on the sachet.

- **Opportunities for Local Cassava and Starch Processing**: To avoid import dependency, the policy can be structured to incentivize local agro-industrial innovation. Nigeria is the world's largest producer of cassava. With targeted institutional support, local starch processing plants (such as those in Oyo, Edo, and Delta states) can scale operations to chemically modify local cassava starch into resistant starches and functional dextrins. This regulatory shift can transition from an industry burden into a powerful driver of backward integration, boosting the domestic agricultural value chain and reducing import reliance [20].

Conclusion and Policy Recommendation

Derivation and Rationale for a Pragmatic Dual-Cap Framework

To engineer a policy proposal that is both biologically effective and commercially viable, we recommend that NAFDAC bypass isolated sugar metrics and instead implement a **dual-cap regulatory framework: a mandatory Total Glycemic Carbohydrate Cap of 45g/100g paired with a mandatory Total Fat Ceiling of 30g/100g**.

The mathematical and logistical derivation for this specific policy threshold is established as follows:

- **The Carbohydrate Boundary**: We target a baseline where heavy daily adult exposure (three 12g sachets; 36g total mass) remains safely around **30%** of the WHO daily free sugar allowance (50g).

36 g (Product Mass) × 0.45 (Carbohydrate Concentration) = **16.2 g** of carbohydrate

(16.2 g ÷ 50 g) × 100 = 32.4% ≈ 30% Safety Target

A threshold of **45g/100g** serves as a pragmatic sweet spot. It forces high-carbohydrate brands like *Kivo* (65g) and *Kremela* (60g) to cut their carbohydrate composition significantly, creating a manageable formula volume gap (15% to 20% of dry mass) for local factories to adjust.

- **The Fat Ceiling**: To prevent manufacturers from exploiting food safety loopholes—such as stuffing the missing volume with dense lipid stabilizers that trigger caloric spikes—the carbohydrate cap is legally locked to a **30g/100g total fat limit**. This density matches international baseline definitions for functional whitening powders while blocking lipid overload.
- **The Reformulation Incentive**: This twin restriction eliminates cheap glucose syrups and excess hydrogenated oils simultaneously. To close the labeling loophole effectively, **regulators must mandate that glucose syrup solids be legally grouped under "Added Sugars" or "Free Sugars" rather than "Complex Carbohydrates" on panels.** This regulatory shift structurally forces the food industry to utilize healthier, non-sweet, genuinely complex low-calorie texturizers like **soluble dietary fibers**

(inulin, polydextrose) or **resistant starches**. These alternatives protect the powder's shelf stability and prevent moisture clumping in tropical climates without triggering glycemic or cardiovascular spikes.

Strategic Action Plan for NAFDAC, SON, and NGOs

- **Codify the Dual-Cap Mandate with a Phased 24-Month Grace Period**: Update National Industrial Standard (NIS) 340 guidelines to legally restrict creamers to ≤ 45g carbohydrate and ≤ 30g fat per 100g dry weight. Provide a 24-month transition window to allow local manufacturing lines to reformulate their recipes and modify their supply chains safely.
- **Redefine Carbohydrate Classification**: Mandate that all hydrolyzed starch derivatives with a glycemic index above 80 (e.g., glucose syrup solids, maltodextrin) be declared as free or added sugars on retail nutrition blocks.
- **Enforce Front-of-Pack Nutrition Labeling (FOPL)**: Mandate high-visibility warning symbols on the front of all sachet packaging explicitly stating **"HIGH IN HIDDEN SUGAR/CARBOHYDRATE"** or **"HIGH IN FAT"** [21].
- **Restrict Deceptive Visual Marketing**: Prohibit the use of images depicting dairy cows, streams of fluid milk, or teaspoons pouring milk-like powder on packaging for products chemically derived from vegetable oils and sugars. Labels must clearly display a high-contrast front-of-pack disclaimer: **"NOT A MILK SUBSTITUTE - NOT SUITABLE FOR INFANT FEEDING"**.
- **Provide Centralized Agro-Industrial Research Grants**: Partner with the Federal Ministry of Agriculture and Food Security to fund local starch processors, accelerating the domestic production of functional resistant starches from cassava to serve as cheap, healthy bulking alternatives.

Declarations

Clinical Application Number, Ethics Approval and Consent to Participate

Not applicable. This study evaluates publicly available, secondary packaging labels and did not involve human participants.

Consent for Publication

Not applicable.

Availability of Data and Materials

The dataset supporting the conclusions of this article is derived directly from commercial retail product labels available in Nigerian markets and is fully displayed within the text.

Competing Interests

The authors declare that they have no competing interests.

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Authors' Contributions

All authors contributed equally to the conceptual design, transcription of label data, exposure simulation modeling, epidemiological relative risk modeling, characterization of systemic and product-specific free sugar risk factors, economic impact analysis, policy derivation, and manuscript drafting. All authors read and approved the final manuscript.

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