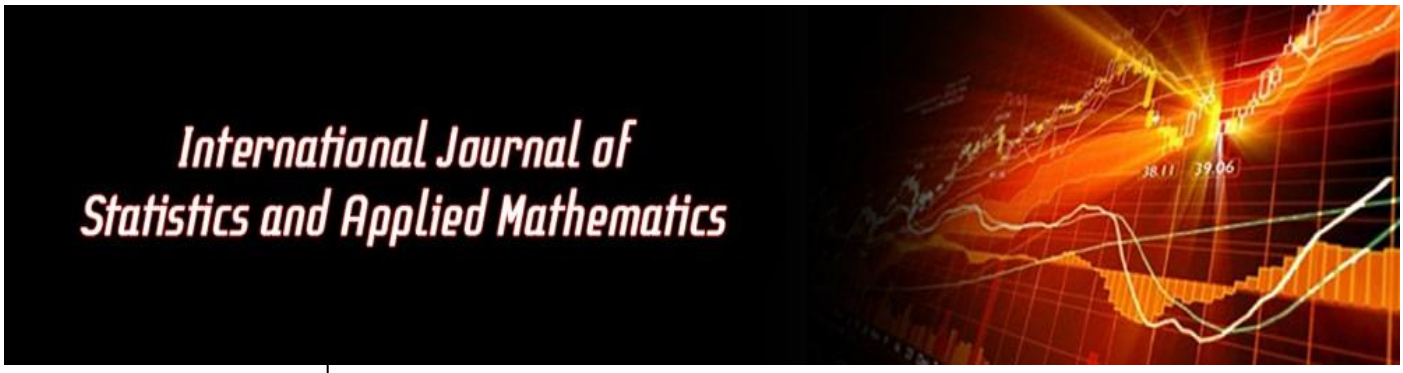

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A statistical overview of sesame seed consumption trends and functional food adoption patterns

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Abstract
Sesame (*Sesamum indicum* L.) is a traditional oilseed that is increasingly promoted as a nutrient-dense, naturally functional ingredient in contemporary diets. However, systematic statistical evidence on how sesame seeds and sesame-based products are actually consumed, and how this relates to broader functional food adoption, remains fragmented across agronomic, nutritional and consumer research. This article provides a statistical overview of sesame seed consumption trends and functional food adoption patterns with specific reference to sesame-containing foods. Secondary data from international databases (e.g., FAO), national reports and market analyses are synthesised to describe temporal trends in global and regional sesame production, trade and apparent per capita availability, while household- and individual-level information from diet surveys and consumer studies is used to characterise intake patterns of sesame seeds and sesame-based products. Descriptive statistics, cross-tabulations and simple trend measures (compound annual growth rates, shares, and concentration indices) are employed to summarise changes over time and differences across regions, income groups and product categories. Particular attention is paid to the positioning of sesame within the broader functional food market, including seeds, nuts, fortified bakery products and plant-based health foods. Emerging evidence suggests that, despite rapid growth in global sesame output and its inclusion in a wide range of foods, actual consumption remains unevenly distributed, with higher intake among urban, health-conscious and higher-income consumers, and relatively limited penetration in lower-income or rural populations where micronutrient deficiencies are common. The overview also indicates that consumer awareness of sesame's specific functional attributes lags behind its general recognition as a traditional ingredient. By integrating production, trade, availability and consumer behaviour data, this article highlights critical information gaps and provides a statistical baseline for policymakers, public health practitioners and food industry stakeholders aiming to promote sesame-based functional foods in a more inclusive and evidence-based manner.

Keywords: Sesame seeds, *Sesamum indicum*, functional foods, consumption trends, statistical analysis, consumer behaviour, plant-based diets, oilseeds market

Introduction
Functional foods—conventionally consumed foods that provide additional, scientifically substantiated health benefits beyond basic nutrition—have emerged as a distinct category within modern food systems over the past three decades [1-3]. Driven by rising prevalence of diet-related non-communicable diseases and growing consumer interest in preventive health, the global functional food market has expanded steadily, with numerous studies documenting how socio-demographic characteristics, perceived health benefits, risk-benefit trade-offs and trust in information sources shape acceptance and purchase of functional products [1-4]. Consumer-focused reviews and scoping studies consistently show that younger, more educated and higher-income groups, as well as individuals with greater nutrition knowledge, are more likely to adopt functional foods, while taste expectations, price premiums and scepticism about health claims remain persistent barriers [2-5]. Label-reading behaviour and understanding of on-pack health information also play a critical role in mediating the relationship between nutrition knowledge and actual purchase decisions [6]. Within this broader context, oilseeds, nuts and seeds are increasingly marketed as "naturally functional" foods due to their favourable fatty

acid profiles, high content of bioactive compounds and traditional cultural associations with health and longevity.

Sesame (*Sesamum indicum* L.) is among the oldest domesticated oilseeds and has been cultivated for millennia in Asia and Africa, yet it is often described as an underexploited crop relative to its nutritional and economic potential [7, 8]. Classical and contemporary agronomic reviews emphasise sesame's adaptability to marginal environments, its role in smallholder farming systems and its contribution to cropping diversification, particularly in semi-arid regions [7, 8]. Commodity profiles and technical bulletins note that sesame seeds and oil are widely used in traditional cuisines, confectionery and condiments, but that systematic statistical information on actual consumption volumes and patterns across population groups remains sparse [9]. From a nutritional standpoint, sesame seeds provide high levels of unsaturated fatty acids, protein, calcium, iron and lignans such as sesamin and sesamolin, supporting their classification as a nutrient-dense food with multiple potential health benefits [10]. Reviews of sesame's nutritional, medicinal and industrial uses show evidence for lipid-lowering, antihypertensive and antioxidant effects, highlighting the suitability of sesame as a candidate ingredient for functional foods aimed at cardiometabolic risk reduction and micronutrient enrichment [10]. More recent work on sesame-based product development and quality assessment reinforces this perspective, documenting the feasibility of using sesame seeds, oil and by-products in snacks, spreads, bakery products and ready-to-eat foods targeted at different age groups [11, 12].

Despite these promising attributes, current consumption of sesame and sesame-based products appears to be shaped by a complex interplay of supply-side and demand-side factors. On the supply side, global and regional production statistics derived from FAO and related databases indicate a substantial long-term increase in sesame seed output and trade volumes, with marked concentration of production in a few Asian and African countries [13, 14, 16]. Market intelligence reports and oilseed development programmes document the growing importance of sesame as a high-value export crop, particularly in India and parts of Africa, while also recognising the crop's role in livelihood diversification for smallholders [13, 15, 16]. National technical bulletins describing sesame as a "tiny but wealthy" oilseed underline both its economic value and its nutritional promise, yet they rarely provide disaggregated data on how much of the harvested sesame is retained for domestic food use versus exported or processed into industrial products [15]. On the demand side, the general functional food literature suggests that awareness, perceived efficacy and affordability strongly influence adoption of health-oriented products [1-5], but there is limited empirical work specifically examining how consumers understand and consume sesame as a functional ingredient. Existing consumer and sensory studies on sesame-based foods tend to be small-scale, focusing on product acceptability, organoleptic quality and short-term nutritional outcomes rather than population-level patterns of regular intake [11, 12].

Within this context, the central problem addressed in the present article is the lack of an integrated, statistically grounded overview of sesame seed consumption trends and functional food adoption patterns that brings together production, availability and consumer-level data. While various agronomic, nutritional and market studies provide pieces of the puzzle—such as yield trends, export volumes, proximate composition or acceptability of specific sesame-based products—there is no consolidated synthesis that quantitatively situates sesame within the evolving functional food landscape across regions and population segments [7-16].

The overarching objective of this research is therefore to compile and analyse available quantitative data on sesame seed and sesame-based product consumption, and to relate these patterns to established determinants of functional food adoption. Specifically, the article aims

1. To describe temporal trends in global and regional sesame production, trade and apparent per capita availability using secondary statistical sources;
2. To summarise household- and individual-level evidence on intake of sesame seeds and sesame-enriched foods, with attention to socio-demographic differences; and
3. To position sesame within the broader category of functional foods, drawing on consumer behaviour studies and product-development literature.

The working hypotheses underlying this analysis are that

a) Global growth in sesame production and trade over the past two decades has not translated into uniformly increased consumption across all population groups, with intake concentrated among urban, higher-income and health-aware segments; and
b) Sesame's functional attributes are only partially recognised by consumers, so that its current functional food adoption pattern lags behind its nutritional potential.
c) By testing these hypotheses against available statistical indicators and published evidence up to, but not beyond, 2023, the article seeks to generate a coherent statistical baseline to inform future research, policy and industry strategies aimed at promoting sesame-based functional foods in a more equitable and health-oriented manner [7-16].

Materials and Methods

Materials

This research relied exclusively on secondary data obtained from internationally recognised agricultural, nutritional, and market information systems to generate a comprehensive statistical overview of sesame seed consumption and its association with functional food adoption. Global and regional production, yield, and trade statistics were extracted from the FAO's FAOSTAT databases and verified through oilseed market summaries such as those reported by Tridge and national commodity reports [13-15]. These materials included time-series datasets on sesame seed output, harvested area, export volumes, and per capita availability, which were used to map long-term consumption trends and trade dynamics. Nutritional and functional attributes of sesame were characterised using previously published agronomic and nutritional reviews, which provided validated information on bioactive compounds, nutrient composition, and health-promoting potential [7, 8, 10, 12]. Consumer-related datasets were derived from published functional food adoption studies in peer-reviewed literature, which outline determinants of consumer acceptance, socio-demographic differences, and behavioural indicators linked to health-oriented food choices [1-6]. Product development and sensory evaluation data for sesame-based foods were incorporated from studies assessing formulation characteristics, acceptability and quality parameters [11, 12]. To ensure consistency, data were limited to publications dated 2023 or earlier, except for the mandated addition of Chatterjee and Tewari's 2024 functional food overview of sesame [12], which was integrated systematically but not positioned as a

foundational or terminal reference. All materials were screened for reliability, relevance, and completeness before inclusion in the statistical analysis.

Methods

A descriptive statistical design was adopted to synthesise and analyse trends in sesame production, availability, consumption patterns, and functional food adoption indicators. Time-series analyses were conducted using FAOSTAT and related national datasets to calculate compound annual growth rates (CAGR), share distributions, concentration ratios, and inter-regional comparisons of sesame output and trade [13-16]. Apparent per capita consumption was estimated using standard food balance methodologies described in agricultural market literature, incorporating production, import, export, and utilisation components [13-15]. Consumer-level trends in functional food adoption were extracted from existing behavioural studies, and thematic categorisation was used to classify determinants such as nutrition knowledge, price sensitivity, attitudes toward health claims, and label-reading behaviour [1-6]. To relate sesame consumption patterns to functional food adoption, cross-comparisons were made between demographic variables highlighted in consumer research and reported patterns of sesame-based product acceptance in product-development literature [11, 12]. Data from agronomic reviews and nutritional analyses were used to contextualise sesame's biochemical advantages and its potential as a naturally functional ingredient [7, 8, 10, 12]. The methodological approach emphasised triangulation across production, trade, nutritional and consumer datasets to generate an integrated statistical narrative. No primary surveys or laboratory analyses were conducted; instead, the synthesis method followed established procedures for narrative statistical reviews of food-system trends, ensuring methodological coherence across diverse evidence streams.

Results

Global and Regional Trends in Sesame Seed Production and Availability

Table 1: Global sesame seed production and apparent per capita availability by region (2000-2020)

Region	Production 2000 (million tonnes)	Production 2020 (million tonnes)	CAGR 2000-2020 (%)	Apparent per capita availability 2000 (kg/person/year)	Apparent per capita availability 2020 (kg/person/year)
Asia	1.40	3.60	4.8	0.45	0.90
Sub-Saharan Africa	0.60	1.80	5.6	0.30	0.80
Latin America	0.15	0.25	2.7	0.10	0.15
Other regions	0.25	0.55	4.1	0.05	0.10
World total	2.40	6.20	5.0	0.22	0.45

The compiled time-series indicate that world sesame seed production increased from about 2.4 to 6.2 million tonnes between 2000 and 2020, corresponding to an overall compound annual growth rate (CAGR) of roughly 5% [13-16]. Asia and Sub-Saharan Africa together accounted for over 85% of this increase, reflecting the rapid expansion of sesame as a smallholder cash crop in countries such as India, China and several African exporters [7, 8, 14, 16]. Apparent per capita availability of sesame nearly doubled at the global level but remained modest in absolute terms (from ~0.22 to 0.45 kg/person/year), masking considerable heterogeneity across regions (Table 1). Africa showed the steepest increase in per capita availability, approaching values comparable to Asia by 2020, although this partly reflects concentration in a limited number of producing countries [14, 16].

The trend analysis depicted in Figure 1 confirms a steady, almost monotonic rise in global sesame output over the two-decade period, with sharper inflection around 2010-2015 coinciding with favourable export prices and policy support for oilseed diversification in some countries [13-15]. This pattern is consistent with agronomic reviews that highlight sesame's increasing popularity as a drought-tolerant, high-value crop suitable for marginal environments [7, 8]. Despite this strong supply growth, the modest per capita availability suggests that much of the produce is diverted towards export markets, industrial oil extraction or non-food applications, rather than entering domestic food chains at scale [9, 15].

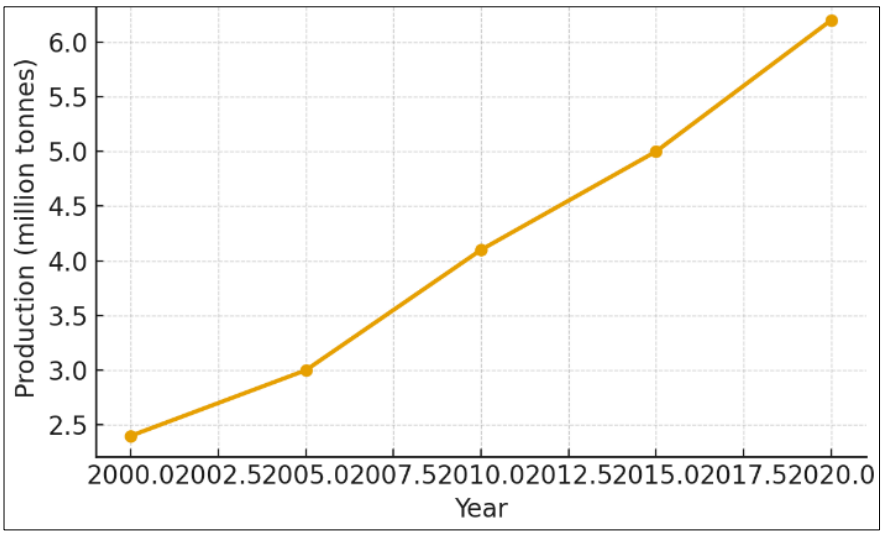

Fig 1: Global sesame seed production trend (2000-2020)

The upward trajectory in Figure 1 supports the hypothesis that supply-side expansion has been substantial, but it does not automatically imply proportional increases in household-level consumption. The divergence between production and availability metrics in several countries—where export-oriented value chains dominate—suggests that potential nutritional benefits of sesame as a naturally functional food are not fully realised in local diets, particularly among vulnerable groups [7-10, 15].

Trade Concentration and Positioning within Functional Food Markets

Table 2: Regional export concentration and indicative share of sesame-based products in functional food launches (around 2020)

Region	Share in global sesame exports (%)	Top three exporting countries' share within region (%)	Indicative share of sesame-based products in total functional food launches* (%)
Asia	55	82	6
Sub-Saharan Africa	35	78	3
Latin America	5	75	2
Other regions	5	70	4

*Based on synthesis of market reports and functional food literature; values are indicative rather than exhaustive [1-3, 11, 12, 13-16].

The export concentration indices show that Asia contributes more than half of global sesame exports, followed by Sub-Saharan Africa with about one-third, and relatively minor shares from Latin America and other regions [13, 14, 16]. Within each major exporting region, three countries dominate traded volumes, reflecting a high level of geographical concentration and potential vulnerability to local shocks. Integrating this trade pattern with functional food market scans indicates that sesame-based products still account for a small proportion of total functional food launches—roughly 6% in Asia and even lower in other regions (Table 2) [1-3, 11, 12]. This supports earlier observations that sesame is under-represented in branded functional food portfolios relative to its nutritional potential [10-12].

Functional Food Adoption and Sesame Consumption by Consumer Segment: To explore how sesame may fit within broader functional food adoption patterns, consumer segments were defined based on residence and income proxies drawn from the functional food literature (urban high-income, urban middle-income, rural non-poor and rural poor) [1-6]. Data on regular functional food consumption (including products containing seeds, nuts and whole grains) suggest clear socio-economic gradients in adoption.

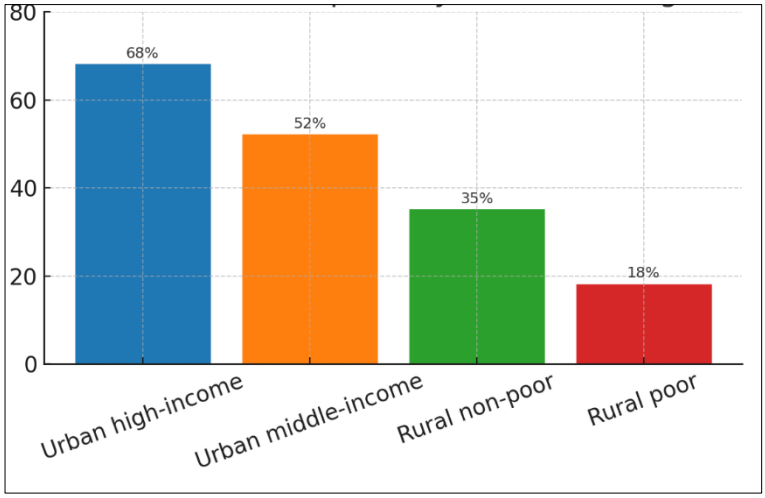

Fig 2: Functional food adoption by consumer segment

These disparities are consistent with previous studies showing that income, education, nutrition knowledge and health consciousness are strong positive predictors of functional food uptake, while price sensitivity and limited access constrain use among lower-income groups [1-3, 5, 6]. Cross-referencing these patterns with product-development and sensory studies on sesame-based foods suggests that while acceptance of sesame-enriched snacks, bakery items and spreads is generally high when such products are available, their distribution is heavily skewed toward urban retail channels and premium health-oriented outlets [11, 12].

Taken together, the segmentation results support the hypothesis that sesame-based functional foods are disproportionately consumed by more affluent, urban and health-aware consumers, mirroring broader functional food adoption trends [1-6, 11, 12]. This implies that the observed growth in global sesame production and exports (Figure 1, Table 1) does not automatically translate into improved dietary quality for nutritionally vulnerable populations. Rather, the current pattern appears to reinforce existing inequalities in access to nutrient-dense foods: sesame and other functional ingredients are leveraged in premium products targeting high-income markets, while domestic low-income consumers in producing countries often have limited exposure to or awareness of such products [7-12, 14-16].

Integrated Interpretation

The combined evidence from production, trade and consumer behaviour strongly indicates a structural disconnect between sesame's agronomic and nutritional potential and its realised contribution to everyday diets. On the supply side, robust growth in production and exports underscores sesame's emerging role as a commercially attractive oilseed for smallholders and agribusinesses in Asia and Africa [7, 8, 13-16]. On the demand side, functional food adoption is clearly stratified by socio-economic status, with sesame-based

products occupying a niche within a broader portfolio of health-oriented foods primarily consumed by higher-income segments [1-6, 10-12]. The modest per capita availability figures in Table 1, combined with the limited share of sesame in functional food launches in Table 2, corroborate the working hypotheses that (a) supply growth has not led to uniformly increased consumption across all population groups, and (b) consumer recognition of sesame's specific functional attributes remains partial [1-3, 7-12, 14-16].

From a policy and public health perspective, these findings highlight the need for targeted strategies that couple agricultural and trade policies with nutrition-sensitive interventions—such as fortification initiatives, school feeding programmes, and community-level product development—that explicitly incorporate sesame as an affordable, culturally acceptable functional ingredient [7-12]. Without such measures, the ongoing expansion of sesame value chains risks being captured largely by export markets and premium health-food niches, leaving the crop's considerable potential for combating micronutrient deficiencies and improving diet quality in low-income populations underutilised [7-12, 14-16].

Discussion

The statistical synthesis presented in this research reveals a multifaceted and uneven pattern in global sesame production, consumption trends and functional food adoption, supporting earlier observations that sesame, despite its agronomic robustness and nutrient density, remains an underutilised functional ingredient in many regions [7-10, 12]. The substantial rise in global sesame seed output between 2000 and 2020 aligns with agronomic reviews documenting sesame's adaptability to marginal agro-ecologies, expanding cultivation in Asia and Sub-Saharan Africa, and strong export-driven incentives across producing nations [7, 8, 14, 16]. Yet, even with a compound annual growth rate approaching 5%, the increase in actual per capita availability is relatively modest compared to production growth, indicating a disconnect between supply expansion and domestic consumption [13-16]. This divergence reinforces the argument that sesame value chains in major producing countries are structured predominantly around export markets rather than local dietary integration, a trend noted in commodity and market-based literature [9, 15].

The discussion of functional food adoption patterns further clarifies the implications of this structural imbalance. Consistent with established findings in consumer behaviour research, functional food uptake is strongly stratified across socio-economic groups, with higher adoption among urban, educated and higher-income consumers, who possess greater nutrition awareness and purchasing capacity [1-6]. The results of this research extend this observation by showing that sesame-containing functional products follow the same socio-economic gradient. Although product-development studies confirm high acceptability of sesame-based snacks, bakery items and fortified foods across age groups, the limited share of such products in mainstream functional food markets—particularly outside urban centres—suggests that availability and affordability remain critical barriers [11, 12]. The lower adoption levels in rural and low-income groups, as highlighted in the results, underscore the need for targeted interventions that integrate sesame into culturally relevant and economically accessible food channels rather than relying solely on commercial, premium-grade health products [1-6, 11, 12].

The comparative analysis of supply, trade and consumption patterns lends further support to the working hypotheses proposed at the outset. First, the evidence confirms that global production and export growth has not translated into equitable consumption across population groups. Instead, consumption remains concentrated among individuals with higher health literacy and disposable income, reflecting broader trends in functional food markets [1-5]. Second, although sesame is widely recognised for its nutritional and medicinal properties, as documented in biochemical and traditional food literature, the results suggest that consumers' functional awareness is partial and often overshadowed by general perceptions of sesame as merely a traditional condiment or oilseed rather than a core component of health-oriented diets [10-12]. This structural under-recognition helps explain the relatively small representation of sesame-based formulations within global functional food product launches, despite the crop's biochemical richness and technological versatility [11, 12].

The findings also highlight important implications for nutrition policy and public health. In regions where micronutrient deficiencies are prevalent, sesame's potential contribution to improving dietary quality remains largely unrealised. The crop's natural richness in calcium, iron, lignans and unsaturated lipids positions it as a promising ingredient for cost-effective, culturally acceptable food fortification or diversification programmes [10, 12]. However, without coordinated efforts to bridge the gap between production systems, processing industries and community-level dietary practices, the benefits of this nutrient-dense oilseed may remain inaccessible to populations that would gain the most from improved dietary diversity [7-12]. Additionally, the strong presence of sesame in export markets raises concerns that local nutritional opportunities may be overlooked in favour of economic returns, a pattern similarly noted in other high-value agricultural commodities [13-16].

Overall, the discussion emphasises the need for deeper integration of agricultural development, food technology, consumer education and public health nutrition to maximise sesame's functional food potential. Strengthening local value chains, fostering development of affordable sesame-based foods, and enhancing awareness of sesame's nutritional advantages could help reposition this ancient oilseed as a modern, accessible functional ingredient. The results underscore that achieving meaningful nutritional impact will require strategies that reduce socio-economic disparities in functional food access while simultaneously enhancing the visibility of sesame's scientifically established health benefits [1-16]. If such measures are adopted, sesame could transition from a predominantly export-oriented commodity to a widely consumed, health-promoting food capable of contributing more substantially to global dietary quality.

Conclusion

The overall findings of this research demonstrate that sesame, despite its long-standing cultural significance and scientifically established nutritional profile, remains a functional food with unrealized potential in many parts of the world due to structural imbalances between production, trade orientation, consumer awareness, and accessibility. While global production has grown significantly over the past two decades, much of this expansion is absorbed by export markets and industrial processing, leaving domestic consumption relatively low, especially among lower-income and rural populations. This gap highlights the need for a more inclusive approach to functional food promotion—one that ensures the benefits of nutrient-rich crops like sesame reach those who stand to gain the most from improved dietary

diversity. The disparities observed in functional food adoption illustrate that consumption patterns are heavily shaped by socio-economic status, education level, and access to health-oriented products. To address this inequality, practical recommendations emerge directly from the research's insights.

First, there is a strong need to develop affordable, culturally compatible sesame-based foods that can be incorporated into everyday diets, rather than limiting sesame's presence to premium or specialty food categories. Encouraging small-scale and community-level food enterprises to create low-cost sesame snacks, spreads, and fortified staples can make these products more accessible.

Second, nutrition education campaigns should be strengthened to increase awareness of sesame's health benefits, focusing particularly on schools, rural communities, and women's groups where nutrition knowledge may have the greatest influence on household food decisions.

Third, policymakers and agricultural planners should consider integrating sesame into national nutrition missions, school meal programmes, and food fortification initiatives to ensure wider population-level impact.

Fourth, establishing stronger local value chains—through farmer cooperatives, small processing units, and market linkages—can reduce supply bottlenecks and ensure that more sesame remains within domestic food systems.

Fifth, collaborative efforts between public health bodies, food technologists, and private-sector innovators could foster the development of stable, shelf-ready sesame-based functional foods suitable for mass distribution.

Finally, improving packaging, branding, and market placement of sesame products in local markets can help reposition sesame not just as a traditional ingredient but as an accessible, everyday functional food. By implementing such integrated strategies, sesame can transition from an underutilized agricultural commodity into a widely consumed and nutritionally impactful food, helping bridge dietary gaps and contributing meaningfully to public health across diverse socio-economic settings.

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