

Functional Foods as an Intervention for Malnutrition: A Narrative Review of the Literature

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Abstract

Malnutrition is a worldwide health problem, especially in countries with low or intermediate incomes. Even after decades of progress, there are still differences between institutions, limited access to nutrient-dense meals, and food instability. Functional foods, which offer more than just nutrition, could be a long-term answer to problems with macronutrients and micronutrients. The capacity of functional foods to address malnutrition is analyzed through peer-reviewed scientific research, global health statistics, and policy frameworks. The study examines agricultural innovation, public health nutrition, and food science perspectives to identify optimal intervention and delivery approaches. The review says that functional meals that include biofortified staple crops, fermented probiotics, and plant foods high in phytochemicals can help with nutrition, immunological function, and the risk of non-communicable diseases. Case studies demonstrate that effective collaboration among sectors encompasses policy-driven food systems, public-private partnerships, and community-oriented distribution. Incorporating functional elements into normal diets and national dietary recommendations helps minimize malnutrition. They should be included in future global health and food security programs because they offer culturally appropriate, nutritionally superior, and affordable food. To observe their impact, we need long-term investments, involvement from all stakeholders, and policies that are in line with each other.

Keywords: Malnutrition, Functional Food, Nutrition, Micronutrient Deficiencies, Dietary Interventions, Public Health

Introduction

Malnutrition is still one of the biggest health problems in the world, and it affects mostly low- and middle-income countries. Global health research connects it to death,

sickness, and loss of human capital (Kerac et al., 2020; Siddiqui, 2020; Lowe, 2021). Malnutrition, encompassing undernutrition and increasing overnutrition, endures in India notwithstanding advancements in the economy and healthcare (Chowdhury & Ray, 2024; Kaur & Sinha, 2024). Chronic undernutrition causes stunting, wasting, and being underweight, which slows down physical and mental growth. The World Health Organization advises that not getting enough micronutrients, especially iron, vitamin A, and iodine, makes anemia and thyroid diseases worse. Additionally, urbanization and changes in food have led to more diet-related NCDs, including as heart disease, diabetes, and obesity (Meshram, 2024). Undernutrition and overnutrition reveal disparities in structural food access, knowledge, and cost (Das & Bose, 2015).

Functional meals might help with these problems. Fortified foods have omega-3 fatty acids, probiotics, vitamins, and minerals. They have health advantages beyond nutrition (Cencic & Chingwaru, 2010). Fortified rice and wheat enhance micronutrient consumption and mitigate deficiencies-associated diseases (Menrad, 2003). Bioactives also help protect against long-term illnesses (Alongi & Anese, 2021). To work, they have to meet exacting safety, labeling, and fortification standards. For adoption to be sustainable, access, cost, and public awareness need to be improved, especially among people who live in rural areas or are low-income (Tay et al., 2023). Policymakers, researchers, and industry stakeholders must work together across sectors to get the most out of functional meals' anti-malnutrition advantages. This study aims to:

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- Examine the dual burden of undernutrition and overnutrition in India.
- Assess the potential of functional foods in improving nutritional outcomes.
- Evaluate functional foods and their integration within public health policies; and
- Identify barriers related to awareness, affordability, and access of functional foods.

Literature Review

Malnutrition in India

India's malnutrition problem hasn't gotten better even though the economy has grown, and the government has started nutrition programs. National surveys indicate that stunting and wasting are prevalent among children under five, particularly in rural and low-income regions (Chowdhury & Ray, 2024; Kaur & Sinha, 2024). Chronic undernutrition stunts cognitive and physical growth, which makes adults less likely to go to school and work. The 2018 WHO report says that malnutrition causes health problems because of a lack of protein and calories, as well as a lack of micronutrients like iron, vitamin A, and iodine. Urbanization and the use of processed, calorie-dense foods have intensified obesity and other diet-related non-communicable diseases (Meshram et al., 2024). This "nutrition transition" has led to new public health problems, making India a global example of the twin cost of malnutrition. Nutritional inequality is caused by things like economic disparity, not being able to get nutrient-rich foods, and not knowing how to eat a balanced diet.

Nutrition and Functional Foods

Functional meals are being looked at as a way to feed a growing population in a way that is good for the environment. Fortified foods contain bioactive vitamins, minerals, omega-3s, probiotics, and antioxidants (Cencic & Chingwaru, 2010). Studies indicate that food

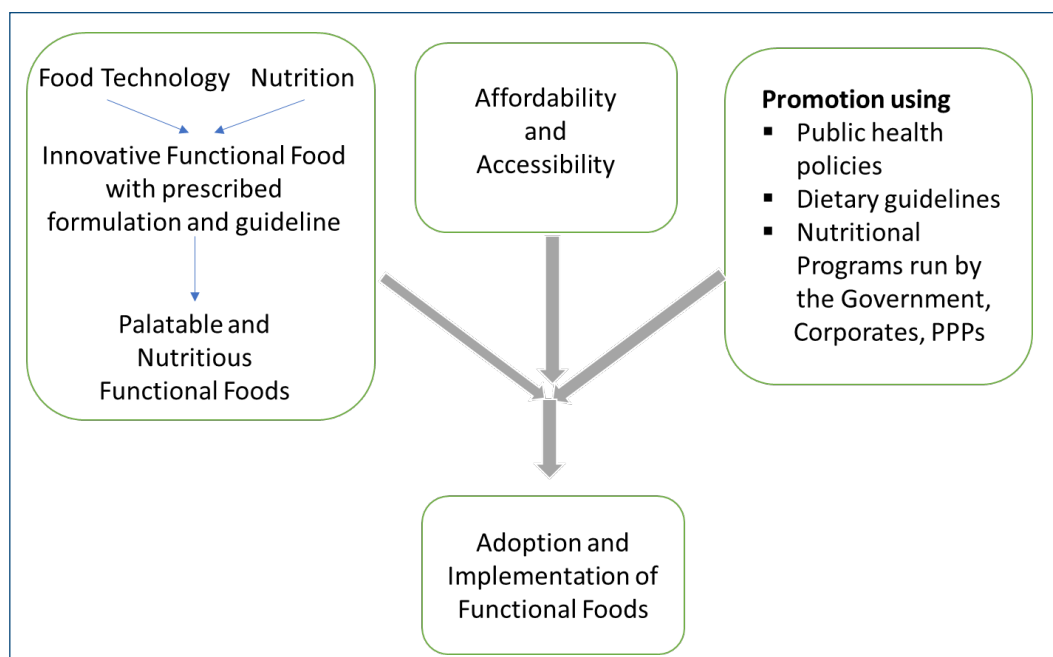
fortification reduces micronutrient deficiencies. Fortified wheat and rice help people in low-income areas get more iron and vitamins (Menrad, 2003). Polyphenols and omega-3 fatty acids in functional foods lessen the risk of heart disease, boost the immune system, and speed up metabolism (Alongi, & Anese, 2021). Functional foods help public health by reducing diet-related NCDs in addition to their health advantages. Their growing market share and customer acceptability indicate that functional food innovation can be included into national nutrition policy.

Rules, Policies, and Access

India is having a hard time adopting functional food, even though it seems to work. For people to trust a product, it needs to be safe, work well, and be of good quality (Baker et al., 2022). This technique needs fortification, labeling, and monitoring after the product is on the market. Functional foods are hard to find in rural and low-income communities because of differences in income and pricing. For people to accept functional foods, they need to be aware of them and learn about them. Studies indicate that the efficacy of functional foods influences dietary adherence and consumer purchasing behavior. Public health campaigns, nutritional education, and subsidies may enhance adoption (Tay et al., 2023).

Nutritional Multidisciplinary Enhancement

Functional food interventions necessitate the integration of food technology, nutritional research, and policy formulation. Technology keeps fortified foods' nutritious value, flavor, and cultural acceptance (Granato et al., 2020). Functional food must be incorporated into national nutrition programs and dietary guidelines to sustain health. For fair and effective nutrition reform, scientists, policymakers, and people in the sector must work together to make sure that scientific advances meet the requirements of the community.



Source: Authors own elaboration.

Fig. 1: Conceptual Framework

Research Methodology

The narrative review looks at how functional meals help prevent malnutrition in India. Employing narrative review standards such as those established by Onwuegbuzie and Frels (2016) guarantees scientific rigor and systematic synthesis. A methodical search of PubMed, Web of Science, and Scopus yielded relevant findings. Research in nutrition science, public health, and food technology was classified into categories such as “functional foods,” “malnutrition,” “nutrition,” “health,” “nutritional supplements,” and “dietary interventions.” Truncation and Boolean operators improved the search coverage. Researchers could “snowball” for more sources by painstakingly going through the reference lists of important articles. Reviews were more thorough.

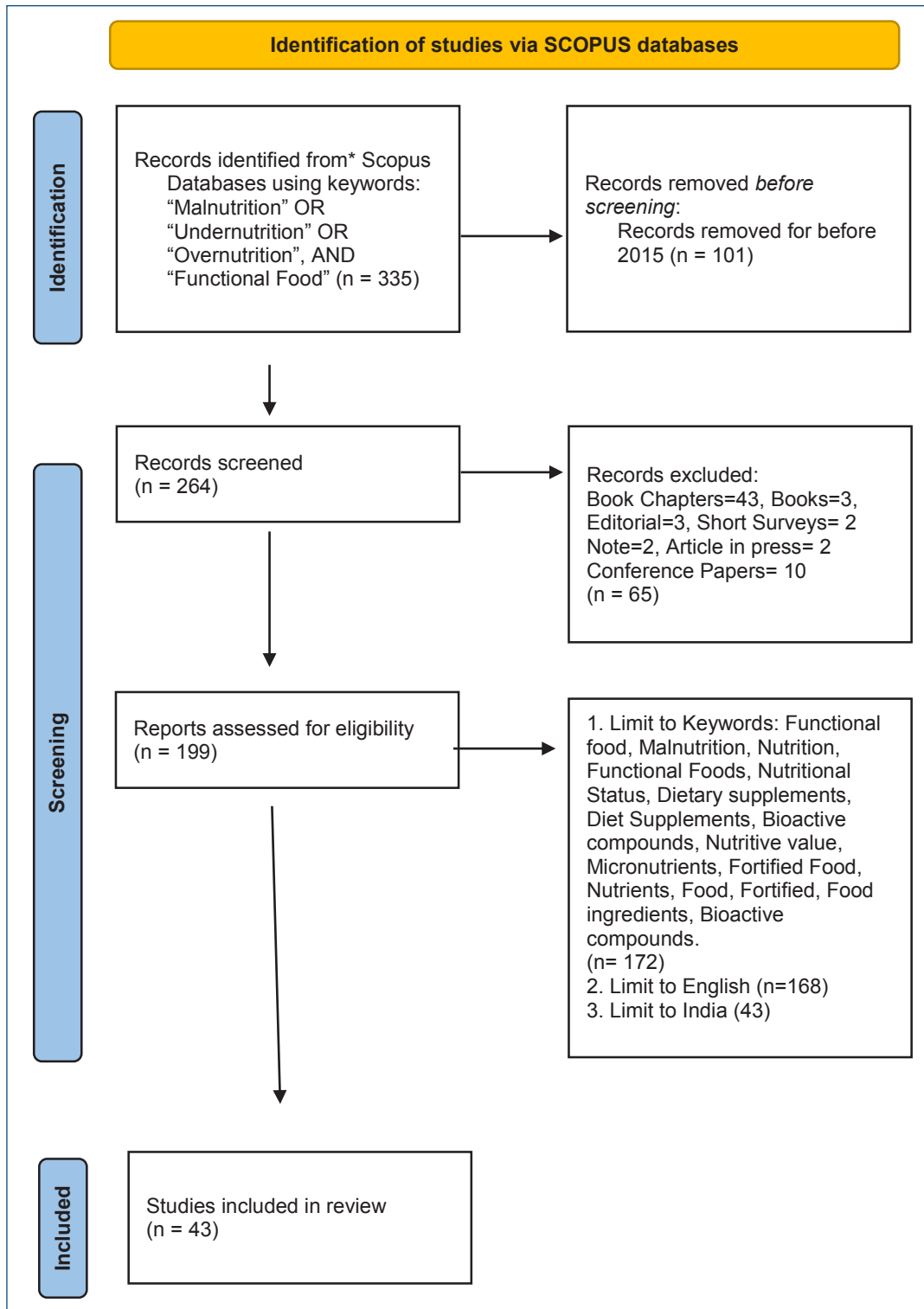
- **Inclusion Criteria:** The study includes academic books, grey literature, and peer-reviewed journal articles in English on functional foods and

malnutrition. The primary focus was on research pertaining to public health, food technology, and nutrition.

- **Exclusion Criteria:** Articles that do not align with the review’s emphasis, are abstracted, published in a different language, or are opinion pieces or secondary interpretations lacking a theoretical framework or original data are excluded.

When putting together the literature, data synthesis looked at themes and study goals. CORE stands for critical examination, organization, reflection, and evaluation. It conveys the story of the findings. The paradigm integrated several viewpoints from diverse fields to enhance comprehension of how functional foods could augment Indian nutrition.

The PRISMA flow diagram (Fig. 2) indicates how many articles were found, looked at, and added. The review procedure is easier and can be done again.



Source: Authors own elaboration.

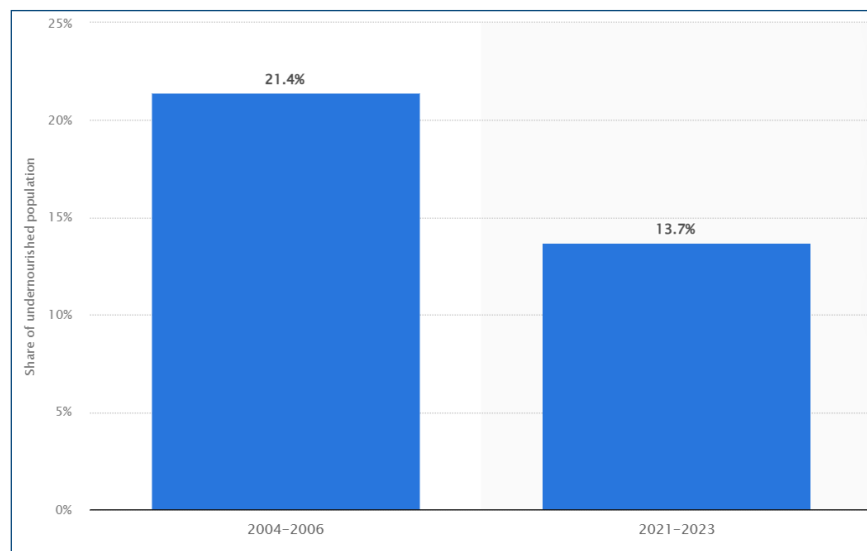
Fig. 2: Prisma Flow Diagram

Findings and Discussion

Malnutrition remains a significant global public health issue, particularly in low- and middle-income countries. This study investigates the potential of functional meals as a supplementary approach for alleviating nutritional deficiencies. Functional meals can be employed as an efficacious approach to improve the nutritional condition of vulnerable populations. The analysis results in the following conclusion:

Comprehending Malnutrition in India

Malnutrition is a complex and widespread problem that impacts numerous demographic groups across extensive geographical regions, representing a considerable threat to India (Singh et al., 2023). The most obvious effect is the high number of children that are underweight, stunted, or wasted. Furthermore, research indicates that disadvantaged children possess insufficient diets, significantly contributing to malnutrition (Khan & Raza, 2016). Malnutrition has a significant impact on both mental and physical development.



Source: Statista.com

Fig. 3: Undernourishment in India

Table 1: Malnutrition Statistics of India

Child Malnutrition (Under 5 years)				
Indicator	1998-99 (NFHS-2)	2005-06 (NFHS-3)	2015-16 (NFHS-4)	2019-21 (NFHS-5)
Stunting	51%	48%	38.40%	35.50%
Wasting	20%	20%	21%	19.30%
Underweight	43%	43%	35.80%	32.10%
Women Malnutrition (15-49 years)				
Indicator	1998-99 (NFHS-2)	2005-06 (NFHS-3)	2015-16 (NFHS-4)	2019-21 (NFHS-5)
Malnutrition (BMI < 18.5)	35.80%	35.50%	22.90%	18.70%

Source: NHFS-2, NHFS-3, NHFS-4, and NHFS-5 (IIPS & ORC Macro., 2000, IIPS & Macro International., 2007, IIPS & ICF., 2017, IIPS, & ICF., 2020).

Table 2: Global Health Index

Year	Rank out of 127 Countries	GHI Score
2024	105	27.3

Source: GHI 2024 (IFPRI, 2024).

As per Fig. 3 the number of undernourished people in India has reduced significantly from 21.4% in 2004–06 to 13.7% in 2021–23. (Statistica.com). Malnutrition is still a big problem in India, even though things are getting a little better. Table 1 and Table 2 show important numbers. According to the National Family Health Survey, the percentage of kids under five who are short for their age has dropped from 38.4% in 2015–16 to 35.5% in 2019–21. 1) Wasting: The number of people who are wasting (low weight-for-height) has gone down from 21.0% in 2015–16 to 19.3% in 2019–21, 2) Underweight: The number of people who are underweight (low weight-for-age) has gone down from 35.8% in 2015–16 to 32.1% in 2019–21, 3) Women: The number of women aged 15 to 49 who are malnourished has gone down from 22.9% in 2015–16 to 18.7% in 2019–21 and 4) Global Hunger Index: Out of 127 countries, India is at 105 position on the Global Hunger Index (GHI) with a score of 27.3 in 2024. This means that even with advances, hunger is still a severe problem.

Lack of vitamins and minerals, in addition to undernutrition, is causing major public health issues. Lack of vitamins A, iodine, calcium, and iron is common and can slow down physical and mental growth, make the immune system weaker, and make a person more likely to get sick. These deficiencies impact both women and children, particularly those who are pregnant (Chaudhary et al., 2022; Swaminathan et al., 2019). Along with the rise in diet-related noncommunicable diseases (NCDs) like diabetes, obesity, and heart disease (Bishwajit, 2015), India is also becoming more urbanized, changing how people eat, becoming less active, and eating too much fat, salt, and sugar. All of these things make the problem of malnutrition worse. Malnutrition might mean not getting enough food or being overweight (Joy et al., 2017). Many areas of society intentionally work to make diet inequality worse. India's disparities arise from insufficient sanitation, inadequate access to clean water, deficient healthcare facilities, financial imbalance, and inadequate maternal and childcare services (Sharma et al., 2020). Dietary patterns that are common in some regions and cultures make nutritional deficiencies worse in at-risk individuals

because traditional meals generally have too many carbs and not enough vitamins, minerals, and protein (Narayan et al., 2019).

Functional Foods

Functional meals containing bioactive chemicals give you extra health benefits and important nutrients (El-Sohaimy, 2012). Bioactive substances encompass vitamins A, C, D, and E; minerals such as iron, calcium, and zinc; phytochemicals including flavonoids and polyphenols; and probiotics such bifidobacteria and lactobacilli. Researchers have shown that these bioactive chemicals are important in functional foods since they provide more than just nutrition (Ghoshal & Kansal, 2019). Functional foods come in three main types: fortified meals, dairy products with probiotics, and biofortified vegetables. According to Cardoso et al. (2019), fortified foods are foods that have been improved with important nutrients to help those who don't get enough of them. You may see this in flour made from wheat and rice. India is adding more iron and folic acid to foods like rice and wheat bread to make up for vitamins that are missing (Akhtar et al., 2011). Probiotic dairy is different from ordinary dairy. It contains living bacteria that are good for the immune system and digestion (Ashaolu, 2020). Research has shown that the probiotics in yogurt, like bifidobacterium bifidum and lactobacillus acidophilus, are very important for digestion and getting the most nutrients. To fill in nutrient deficiencies, biofortified crops like wheat and rice are cultivated with more critical elements like iron and zinc. For instance, biofortified pearl millet and wheat are grown to give them the nutrients they need. Functional foods are not just grains and dairy; they include a wide range of foods that are made to suit certain nutrient needs and health goals (Erenstein et al., 2022). These meals have a dual function of addressing nutritional deficiencies and promoting overall health, ultimately elevating the quality of life for individuals across all socioeconomic and demographic strata (Birch & Bonwick, 2019).

Things That Stop People from Accepting and Eating Functional Foods

Functional meals, however, hold significant potential to enhance health outcomes. But their general acceptability in India is an issue (Baker et al., 2022). Affordability is

a major issue, especially for people with low incomes, because fortified foods are usually more expensive than regular meals, which makes it harder for them to get functional foods (Urala & Lahteenmaki, 2004; Sinha et al., 2023). Another problem is that certain sites are hard to get to, especially the ones that are far away. Cities lack sufficient secure facilities for the storage and distribution of perishable goods, complicating access to functional meals (Kotilainen et al., 2024). People also have trouble accepting functional meals since they know a lot about them, have cultural preferences, and have taste concerns. Studies show that people often stick to traditional diets, which may not meet their current nutritional needs (Baker et al., 2022; Urala & Lahteenmaki, 2004). The Food Safety and Standards Authority of India (FSSAI) is one of the government groups that has worked to make sure that fortified foods are safe and work. The supply chain must follow the rules for fortification and quality control so that enforcement and measurement operate properly.

Suggestions for Getting More People to Eat Healthy Food

To get people to eat healthier, the government, businesses, and non-profits need to work together on a lot of different projects. To stop malnutrition, the government, businesses, and communities need to work together.

What the Government Does

Functional meals are one of several ways the government tries to help those who are malnourished (G and Gupta, 2014). The National Food Fortification Program (NFFP) fortifies rice, wheat flour, and oils to make up for nutritional gaps (Kaur, 2021). The Mid-Day Meal Scheme (MDMS) from the Ministry of Education delivers students free, fortified lunches to help them eat better (Paltasingh & Bhue, 2022). Integrated Child Development Services (ICDS) helps fight hunger by giving more food to pregnant women, new parents, and kids under 6 (Joe et al., 2022). The Anemia Mukht Bharat (AMB) initiative from the government gives people iron and folic acid supplements to stop anemia (Sinha et al., 2019). PMSMA gives iron and calcium supplements to moms and newborns who are not getting enough food. This lowers the number of deaths of mothers and children (Clapp & Scrinis, 2017). Some state governments are using the Fortified Rice Distribution Scheme (FRDS) to help people who don't

get enough vitamins. Under this plan, BPL families get rice that is high in vitamins.

Donations from Businesses

As part of their corporate social responsibility (CSR), companies have started big health and nutrition projects (Clapp, 2021; Mishra, 2021). Companies have pushed for better nutrition, functional foods, and local food and farming systems. Britannia Industries, Nestle India, Hindustan Unilever LTD, ITC Limited, and Cargill India are some of the most important companies. Nestle India's key social responsibility is to add micronutrients to foods (Street, 2015). With help from businesses, Project Poshan teaches poor rural people about food and nutrition. Britannia Industries' Britannia Nutrition Foundation helps people eat healthy, balanced meals. According to a study, their enriched biscuits and other snacks help those who don't get enough nutrients (Bhan, 2019). ITC wants to go to Sunehra Kal. It makes food taste better by mixing iron-fortified staples like Aashirvaad Atta with agricultural goods (Dhal et al., 2023). Hindustan Unilever Ltd. works with local governments and NGOs to help disadvantaged people utilize better salts and edible oils (Soni & Vohra, 2014). Cargill India works with the government and NGOs to make sure that everyone gets what they are owed. Nourishing India is making cooking oils and wheat flour better (Lalani et al., 2019).

Partnerships Between the Public and Private Sectors

PPPs assist Indians create and give healthy, useful meals to people who don't have enough food. The Indian Council of Agricultural Research says that these improvements make it easier to provide nutrients. The Food Fortification Initiative (FFI) adds micronutrients to rice, wheat flour, and oils by bringing together businesses, non-profits, and governments (Roth et al., 2018). You can easily find Mother Dairy's vitamin-enriched milk and Tata Chemicals' iron-enriched salt (Tata Salt Plus). These steps make it easier to obtain meals with a lot of micronutrients in both cities and rural areas of India. The Global Alliance for Improved Nutrition (GAIN) works with businesses, governments, and civil society to improve the environment by pushing for better policies, providing technical support, and expanding the capacity to fortify food (Lalani et al., 2019). Public-private partnerships

(PPPs) bring together private businesses, research groups, and universities to make new things. They make things and sell them. These partnerships come up with new recipes, make nutrients more available, and test the safety and effectiveness of fortified foods (Smyth et al., 2021). These steps are necessary to ensure that India's functional food programs are safe and based on science.

Assessment and Evaluation of Impact

To find out how well functional meals work, you need to make a detailed plan that includes looking at health outcomes, socioeconomic benefits, and nutrient analysis. Policymakers and public health experts are looking into functional food technology as a way to help with India's growing number of health problems caused by bad diets. A full evaluation must consider its long-term effects on biological effectiveness, economic production, public health, and social justice. The following sections examine the health benefits and economic impacts of functional dietary interventions in India.

The Health Benefits of Functional Foods

To find out how well functional foods work in India, you have to deal with a complicated situation where different regions have different eating habits, cultural beliefs, and levels of public health awareness. Some studies, however, have shown that fortified diets can help with serious nutritional deficits. For example, enriched blended food assistance products greatly improved the nutrition of babies and young children in underdeveloped nations. This led to better immunity and lower rates of malnutrition (Pacrez-Exp Asito & Klein, 2009). In India, fortified food programs have a big effect since many women and children still have anemia, which is mostly caused by not getting enough iron. Pandey and Jayachandran (2016) and Pacrez-Exp Asito and Klein (2009) found that biofortification and agricultural-based interventions greatly increased micronutrient intake and health outcomes across South Asia. Kumar et al. (2022) discovered that the consistent intake of iron-rich staples, including millets and fortified rice, elevated hemoglobin levels and diminished the prevalence of anemia among susceptible populations. The decrease in iron deficiency is a significant indicator of the effectiveness of India's extensive food fortification initiatives. Child growth and development are significant health indicators. Precious et

al. (2023) discovered that youngsters consuming fortified meals exhibited markedly enhanced linear development, diminished instances of stunting and wasting, and superior cognitive abilities compared to their non-fortified counterparts.

Effects on Society and the Economy

Even while the costs of starting food security initiatives may seem high, the long-term economic advantages are huge. Wesley and Horton (2011) said that food fortification is one of the most cost-effective public health interventions since it lowers healthcare expenditure and raises productivity. Wimalawansa (2013) also talked about the financial benefits of smart food fortification strategies for minimizing micronutrient shortages. He said that these tactics lead to improved labor productivity and lower disease loads. These results strengthen the financial case for financing nutrition-focused health efforts, particularly in low- and middle-income nations. But India's socioeconomic situation makes it hard to keep up long-term consumption. How well these kinds of projects work rely a lot on people's tastes, the food culture in the area, the price, and how well customers know about them. Drewnowski (2020) suggested creating communication techniques that are appropriate to the situation and building long-term relationships to make sure that fortified meals are available and acceptable to the people they are meant for. Also, the reach and effectiveness of improved food projects depend a lot on good monitoring, getting stakeholders involved, and regular impact assessments. These adaptive systems allow for real-time changes that assist enhance public health outcomes and make programs run more smoothly.

Problems with Evaluation

Functional dietary interventions yield favorable outcomes; nevertheless, their true impact may be difficult to assess. A significant disadvantage is the scarcity of long-term studies evaluating the advantages of functional diets. Also, many studies have tiny sample sizes, no control groups, and design mistakes, which can all make it hard to generalize and trust the results. Also, cultural considerations and how people see functional meals play a big role in whether or not they are accepted. Because of this, impact studies should take these things into account. Malnutrition in India is complicated, so we need to use a

variety of ways to fix it. Functional meals are just one part of a bigger plan. Evaluations that integrate dietary therapy with enhanced healthcare, sanitation, and educational initiatives are more likely to produce extensive and enduring advantages.

Suggestions for Future Research and Policy

To fully understand the potential of functional meals to fight malnutrition in India, future research should focus on large-scale, long-term studies that look at the long-term health effects of functional meals on people from different socioeconomic and geographic backgrounds. More research on genetic and microbiome-related features can also help us find new ways to tailor nutrition, which will make functional food treatments more accurate and useful.

In addition to health outcomes, we need a comprehensive evaluation method that looks at social acceptability, cultural fit, economic feasibility, and societal relevance. This kind of thoroughness can help lawmakers come up with ideas that are not only financially and culturally sound, but also scientifically sound. The following five strategic areas of recommendation are about policies: 1) Putting more money into local production can make functional meals cheaper and easier to get in communities that don't have enough of them, 2) It is important to strengthen laws that require quality control and nutritional fortification standards in order to keep the public's trust and the effectiveness of products, 3) Health experts and government agencies need to work together to promote healthy eating habits, 4) Stimulating research focused on local dietary practices and nutritional deficiencies can facilitate the creation of functional food products that are both culturally suitable and scientifically validated and 5) The government, colleges, businesses, and non-profits all need to work together to come up with new ideas, make food simpler to access, and build a strong food system that focuses on nutrition. By combining scientific research with new laws, India can come up with a long-term, scalable plan for using functional foods to fight hunger and improve public health.

Conclusion

This study emphasizes the potential of functional meals to combat malnutrition in India, where nutritional advancement has been inconsistent, particularly among underprivileged populations. Over time, functional foods like probiotics, biofortified crops, and fortified staples can help make up for missing nutrients. Cultural preferences, accessibility, and expense all make it less likely that people will embrace it. We need a multidisciplinary approach that involves public-private partnerships, better infrastructure, consumer education, and more regulatory monitoring in order to have the most impact. The following fortification criteria would help make functional foods safer and better, which would make people trust them more and lead to better health outcomes. Finally, integrating functional foods to India's nutrition plan could have a big impact on reducing poverty and improving public health. Working together across different sectors makes it easier to get these advantages, which improves health equity and resilience across the country.

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Conflict of Interest

The authors declare here that there is no conflict in the publication of this research.

AI Disclosure

The authors confirm that no AI-based tools were utilized in conducting this research or writing the manuscript. All content is original and reflects the authors' own work.

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