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INNOVATIVE FOOD PRODUCTS - NUTRACEUTICALS AND FUNCTIONAL FOODS

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Review Based Book Chapter

CONSUMER TRENDS AND NUTRIFIED FOOD

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REVIEW BASED BOOK CHAPTER**CONSUMER TRENDS AND NUTRIFIED FOOD**

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Abstract

This chapter explains the market situation, the latest consumer trends, and the positive impact of nutrified foods on human health and well-being. Consumers' increasing awareness of the health benefits of food and its nutritional value is fueling the global nutrified food market. The demand for nutrified foods is rising in developed countries due to growing knowledge of the health benefits of nutrified foods. In 2021, the nutrified foods market reached USD 462.24 billion and is projected to reach USD 721.65 billion by 2027. The market is expected to grow at an annual growth rate of 7.71% between 2022 and 2027. Despite increasing consumer trends, the market faces several challenges that need to be addressed, such as country-specific regulations and health claim substantiation, cost, consumer trust, awareness, and limited availability of nutrified foods. The current chapter explores the opportunities and strategies for developing and promoting innovative and personalized nutrified foods using novel technologies by balancing taste and nutrition, educating consumers, and sustainable practices. This chapter also concludes by proposing a future outlook and recommendations for the nutrified food market, such as technology integration, 3D and 4D food printing, nanotechnology, sustainability focus, and growth and diversification continuation.

Keywords

Nutrified Dense Foods, Healthy Foods, Nutraceutical, Functional Foods, Market Trends

1. Introduction

The nutrified food and consumer trends are key factors in the food industry's change. Consumer trends relate to the patterns of behavior, inclinations, and mindsets that have a substantial influence on the decisions and choices made by consumers in the marketplace. Numerous causes, such as changes in the population, improvements in technology, environmental concerns, cultural values, and personal motives, all have an impact on these patterns. Furthermore, unique desires and standards for food items and services might be created by consumer trends. Nutrified food, on the other hand, refers

to food items that have been enhanced with useful components like vitamins, minerals, probiotics, antioxidants, or plant extracts, providing additional advantages over mere sustenance [1-3].

Originating in Asia, the notion that "food and medicine are one" is now frequently acknowledged in the West. This is in line with a quotation from the classical Greek physician Hippocrates who said, "Let food be thy medicine" [4, 5]. Consumers are increasingly choosing natural and organic foods for their health benefits, and the food industry is offering more options that are rich in nutrients. The nutraceutical revolution has also changed people's eating habits and behaviour, as they seek foods and supplements that can prevent or treat chronic diseases [6, 7].

The growing demand for nutraceutical and nutrified foods requires the industry to establish new global supply chains. Foods are not only meant to satisfy hunger but also to promote health and wellness. Research has shown that diet is related to many chronic diseases, such as heart disease, diabetes, and cancer, and that these can be prevented or reduced by eating foods with more antioxidants and less fat, exclusively saturated fat [5]. The report of FAOSTAT 2023 concerning the prevalence of undernourishment illustrated in Figure 1 emphasizes the critical necessity for interventions that enhance accessibility to nutrified foods, presenting a crucial avenue for addressing undernourishment and its associated health implications [8].

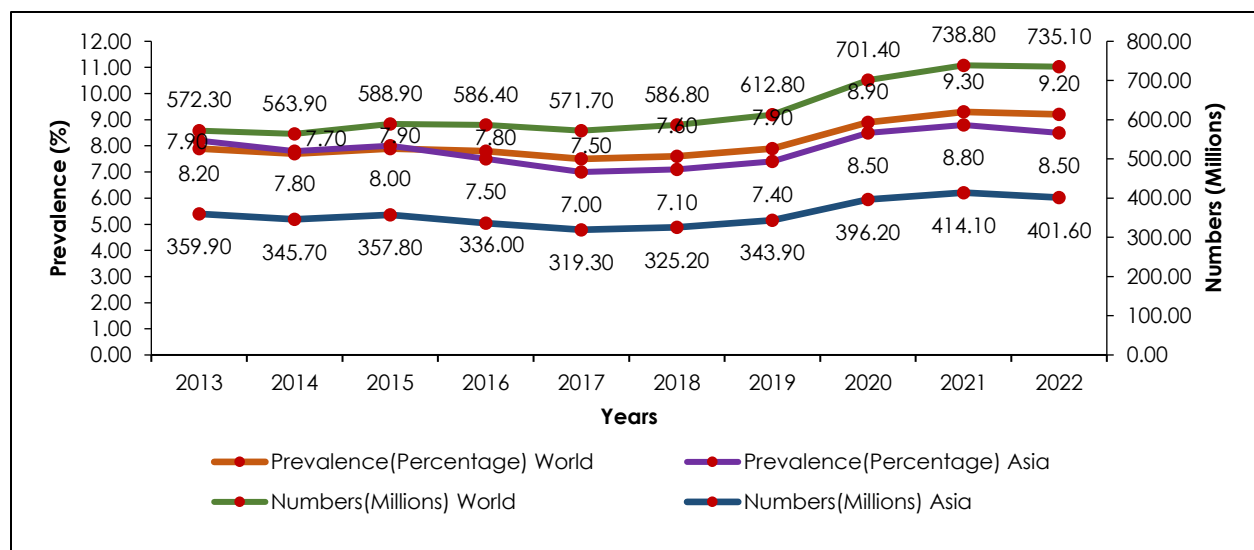


Figure 1 Prevalence of undernourishment in the world and Asia, and the number of undernourished in Asia [8]

Therefore, agriculture and food processing are shifting towards providing foods with added health and nutritional value [4]. Farmers are producing high-yielding and resilient crops and crops with more nutrients to prevent disease and malnutrition. Food manufacturers add value to their products by incorporating specific nutrients or functional ingredients to improve nutrition, immunity, energy, health, and longevity. Various old and new food technologies are used to produce nutritious food and ingredients for healthy food products. Innovation in food technology is vital for transforming nutrition information into consumer products. People want to live long and healthy lives and look for nutritious and functional food that supports their well-being, enjoyment, and active lifestyle [9]. The food industry prioritizes developing healthy foods that provide extra health benefits and incorporates dietary supplements into new food products. For example, breakfast cereals are enriched with minerals and multivitamins, and fruit juices contain glucosamine and chondroitin, which are natural substances that improve joint health. Modern food technology allows people who cannot prepare their healthy foods to get the supplements or nutrients they need from ready-made foods and beverages [4]. This chapter explores the key consumer trends that are shaping the demand and acceptance of nutrified food products and the opportunities and challenges for innovation in this field.

2. Benefits of Nutrified Food

Nutrified foods are enhanced with vital micronutrients that can enhance growth, development, and health while reducing the risk of diseases related to inadequate nutrition; they are particularly advantageous for low- and middle-income nations where nutrient-dense foods are scarce. Nutrified foods can also be tailored to the dietary requirements and preferences of different target groups, such as athletes, vegetarians, vegans, and people with intolerances or allergies [10]. Growing consumer demand in health and wellbeing has raised the demand for and its market capitalization of nutrified foods. Some potential health benefits of nutrified food are shown in Figure 2. Numerous aspects, including the kind, quantity, and bioavailability of the substances, the safety and quality of the food matrix, and any potential interactions or negative effects of the nutrients, affect the nutritional and health results, effectiveness, and quality of nutrified foods. When assessing the effects of nutrified foods, these variables

should be taken into account and suitable methodologies should be applied. Additionally, functional qualities of enriched foods may aid in the management or prevention of chronic conditions like cardiovascular disease, cancer, diabetes, and obesity [11]. Through immune system modulation, molecular mechanism influence, inflammation reduction, cholesterol lowering, blood sugar regulation, gut health promotion, and oxidative stress protection, they achieve this. By offering nutrients that encourage the growth of advantageous bacteria and protect the GI tract from infection, nutrient-rich diets can improve immune function. By incorporating meals high in fiber and fermented foods, they can help improve the function of the digestive tract and aid in digesting. Furthermore, by offering nutrients that enhance the composition and performance of brain cells, nutrified meals can promote brain health. For people of all ages, maintaining a healthy weight, preventing diseases like osteoporosis, hypertension, cardiovascular disease, diabetes, and some types of cancer, and providing energy are all made possible by a good diet [12, 13].

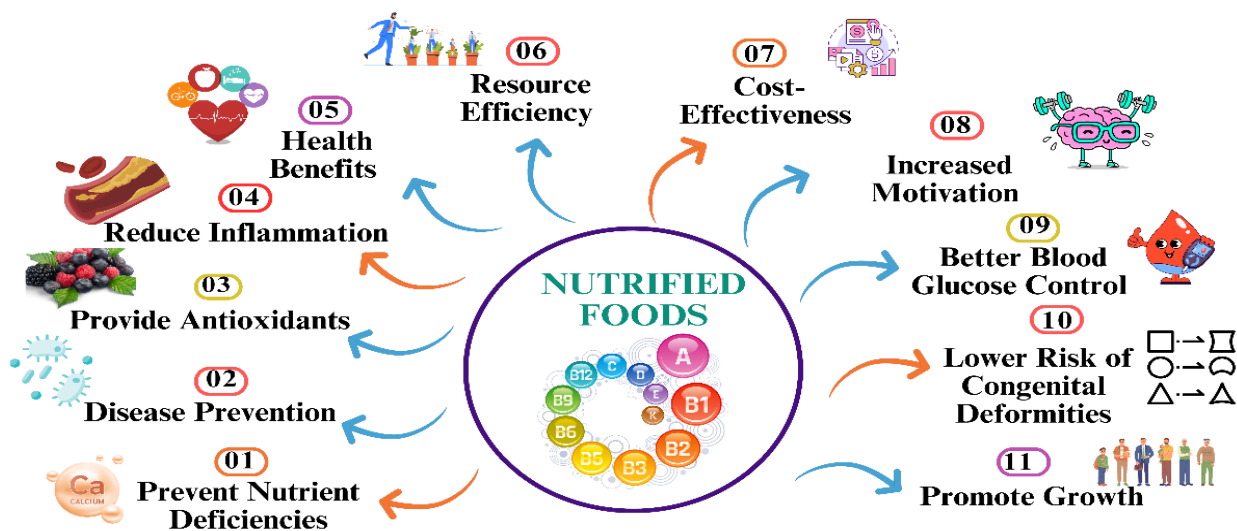


Figure 2 Potential health benefits of Nutrified foods [11-13]

3. Nutrified Food: Market Scenario and Competitive Analysis

Numerous changes in society and demography bolster Nutrified Food, suggesting that its market trend would continue. The aging population, increased consumer interest in health, a movement in nutritional research paradigms to examine the connections

between diet and disease prevention, and support from a range of stakeholders, including the food business, merchants, scientists, and consumer groups, are some of these. The concept of "Nutrified Food" is widely accepted, even though there may not be much consumer awareness of it. Despite low awareness with the word, surveys conducted in several European nations reveal substantial support with fortifying Nutrified components in specific food products [14].

Nutrified foods have become increasingly popular in many spheres of society in recent years for a variety of reasons. First off, a major factor in this expansion has been the rising desire from consumers for items that are enticing, nourishing, and handy. In addition, an aging population has demonstrated a strong conviction in the therapeutic benefits of particular foods and a preference for safer nutritional options requiring less medical intervention. Furthermore, improvements in components, goods, operations, and packaging have made it possible for the food industry to provide additional choices for value-added products thanks to breakthroughs in food technology. Moreover, continuous advancements in the field of nutrition science have expanded our comprehension of the connection between nutrition and overall health. Finally, customers are now aware of the health benefits of specific foods or ingredients thanks to legislative reforms that allow for the increased use of health claim declarations on food products. These various factors have collectively contributed to the tremendous growth of nutrified foods in recent years [15, 16].

According to a report issued by Variant Market Research, the global market is projected to develop at a compound annual growth rate (CAGR) of 7.2% from 2016, increasing \$340 billion in 2024 from \$195 billion in 2016. Geographically, the world's economies are predicted to expand at a CAGR of 7.6% for Asia-Pacific and 7.7% for the rest of the world [5]. Moreover, A report by Precedence Research illustrated in Figure 3 reveals that the size of the worldwide nutraceuticals market was estimated at USD 462.24 billion in 2021 and is projected to grow at a compound annual growth rate (CAGR) of 7.71% to reach USD 721.65 billion by 2027 [17].

The North American region is expanding due to the existence of large producers, ample disposable income, and growing emphasis on looks. In 2021, North America dominated the nutraceuticals market due to increasing health awareness, rising

disposable incomes, a growing ageing population, and increasing sales. Prior to the onset of the pandemic, the U.S. witnessed a steady increase of 5% (\$345 million) in dietary supplement sales in 2019 juxtaposed to the earlier year. However, during the first wave of the pandemic, specifically in the six weeks preceding April 5th, 2020, a significant surge of 44% (\$435 million) in sales indicated a heightened demand for dietary supplements. Notably, demand for multivitamins surged significantly in March 2020, accounting for 51.2% of the total revenue of dietary supplements and vitamins, which came to close to 120 million units during that time. This highlights the increased consumer interest in and reliance on dietary supplements during the early stages of the pandemic in the U.S [17, 18].

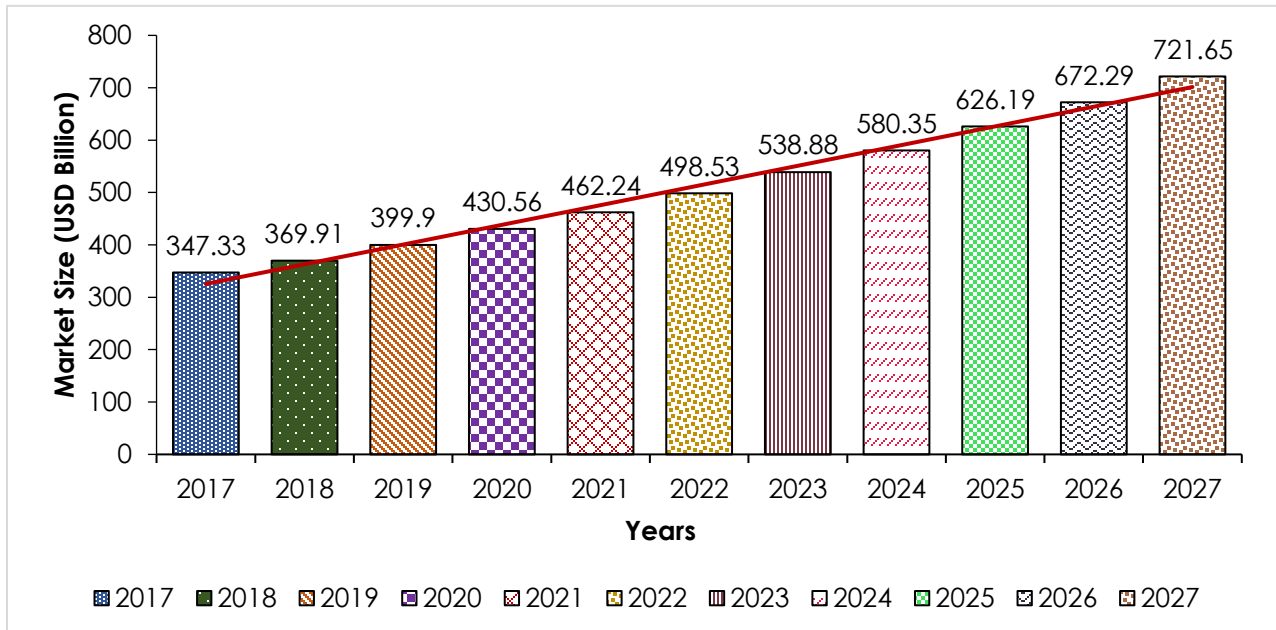


Figure 3 Nutraceutical Market Size 2017 to 2027 (USD Billion) [17]

Conversely, the Indian nutraceuticals market is predicted to grow from \$4 billion in 2017 to \$18 billion in 2025 due to the middle class and upper class' increasing demand for dietary supplements. Furthermore, the market for dietary supplements in India was estimated to be worth USD 3924.44 million in 2020; forecasts indicate that by 2026, it is expected to grow to USD 10,198.57 million. It projects a 22% annual growth rate for the industry [19]. According to a different Precedence Research analysis, the size of the global market for herbal nutraceuticals was predicted to be US\$ 64 billion in 2022 and is

expected to reach approximately US\$ 122.98 billion by 2032, rising at a CAGR of 6.80% from 2023 to 2032, as displayed in Figure 4 [20].

Herbal nutraceuticals are natural supplements that offer health benefits and prevent diseases. They are popular among consumers who want to improve their well-being and avoid chemicals. The global market for herbal nutraceuticals is expected to grow as more people in emerging countries can afford them and access them online. The demand is also driven by the aging population and the prevalence of chronic diseases. Herbal nutraceuticals can help with cholesterol, digestion, and stress. The market will expand as consumers recognize the advantages of herbal products [20, 21].

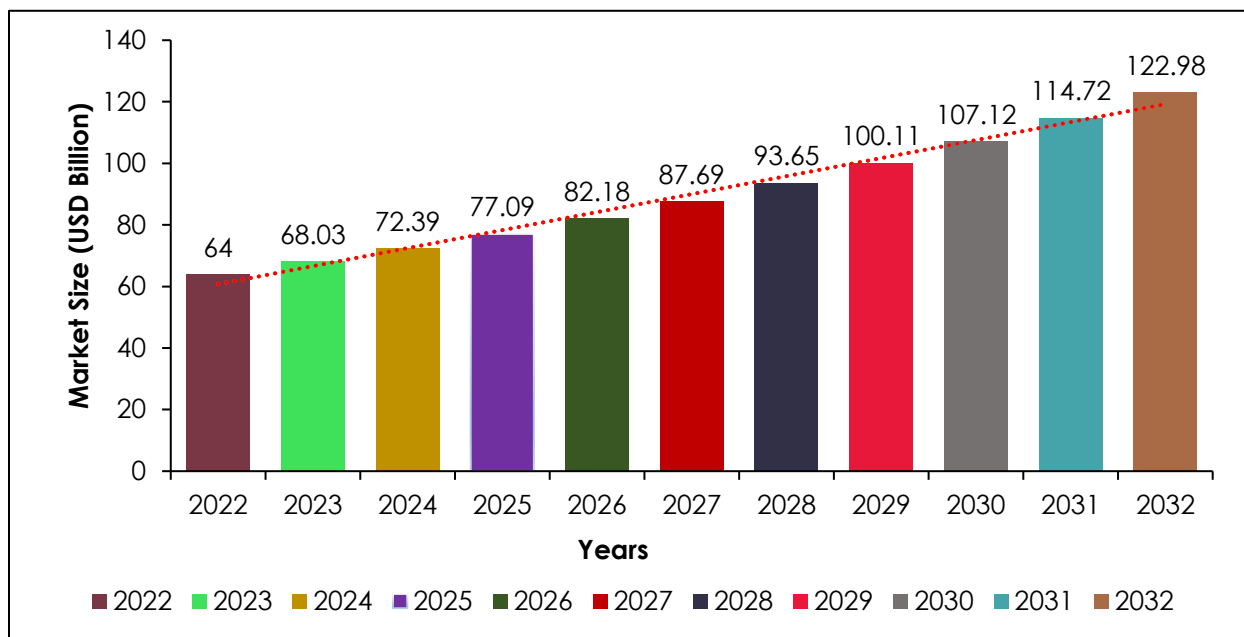


Figure 4 Herbal Nutraceutical Market Size 2022 to 2032 (USD Billion) [20]

4. Challenges of Nutrifed Foods in the Global Market

Nutrified foods can provide various advantages for consumers, such as enhancing immune function, improving cognitive performance, promoting well-being, or preventing or curing diseases. However, in the market, nutrified foods also face a number of challenges and impediments, including those related to availability, price, regulation, customer trust, and knowledge [22].

4.1. Cost Barrier

Nutrient-fortified foods face several obstacles, one among them is the high cost of manufacturing and marketing, which can limit consumer availability and affordability, especially in low- and moderate-income areas. Compared to traditional meals, nutrient-fortified foods frequently require additional R&D, quality assurance, packaging, and marketing, which drives up costs and decreases profitability. For instance, a study showed that the average retail price of fortified foods in India was 24% higher than that of non-fortified foods [23].

4.2. Regulatory and Ethical Issues

Food safety, quality, labelling, health claims, environmental effect, welfare of livestock, and social responsibility are some of the issues that nutrient-fortified foods must contend with. Their validity, credibility, responsibility, and the rights and interests of producers, consumers, and other stakeholders may all be impacted by these issues. It also encounters a complex and diverse regulatory environment, creating uncertainty and inconsistency for producers and consumers. Countries or regions have different regulations and standards for nutrient-fortified foods, depending on how they are classified, labelled, and marketed [24, 25]. Table 1 presents regulatory agencies and regulations of different countries regarding nutrient-fortified foods.

4.3. Consumer Awareness

Another barrier to nutrient-fortified food is low consumer knowledge and awareness, which can influence their adoption and acceptance. Consumers may not have enough education or information about the quality, risks, or benefits of nutrient-fortified foods and may not understand or recognize them. For instance, a survey in China disclosed that only 38% of consumers knew about functional foods, and only 17% could recognize some examples [26, 27].

4.4. Consumer Trust

Some consumers are doubtful, wary, and opposed to nutrient-fortified foods due to their perceived artificiality, safety, and ethical issues. Consumers may also challenge the accuracy and credibility of the health claims made by the manufacturers. This can influence consumer loyalty, behaviour, and attitude towards nutrient-fortified foods and lower the consumer willingness to pay for and buy nutrient-fortified foods. For instance, a study in

Brazil showed that 52% of consumers were worried about the possible side effects of functional foods, and 49% were doubtful about the health claim [28, 29].

Table 1 Nutrified Food Regulations and Standards in different countries [25]

Country	Regulatory Body	Regulations
United States	Several laws and regulations	The Federal Food Drug and Cosmetic Act addresses all foods and food additives, whereas the Dietary Supplement Health and Education Act (DSHEA) regulates dietary supplements. Whereas, manufacturing techniques are covered by the Good Manufacturing Techniques regulations. Additionally, the designation of an orphan medication also promotes the creation of therapeutic foods
European Union	European Food Safety Authority (EFSA)	The EFSA regulates and evaluates claims and sets limits for supplement ingredients. Labels cannot make disease claims; only authorized health claims are allowed. Around 10% of evaluated general health claims were supported by scientific evidence
China	State Food and Drug Administration (SFDA)	The Ministry of Health is in charge of authorizing novel food ingredients, whereas the SFDA is in charge of dietary supplement registration. Imports and exports are strictly regulated by the Administration of Quality Supervision, Inspection, and Quarantine
Japan	Ministry of Health, Labor and Welfare (MHLW)	Nutrient function claims have minimal regulation and require only meeting daily vitamin and mineral levels. Foods for Specialized Health Uses (FOSHU) necessitate pre-marketing consent and promote health benefits. Disease risk reduction claims are not permitted
India	Food Safety and Standards Authority of India (FSSAI)	Compared to medicines, nutraceuticals are subject to less surveillance during manufacturing in India and are governed by the Food Safety and Standards Act (FSSA). The ability of Indian producers to export nutraceuticals might be affected by this

4.5. Availability of Nutrified Foods

Nutrified foods are foods with improved nutritional or functional properties. Due to the lack of infrastructure, consumer demand and distribution channels, they face the challenge of low availability in some regions and markets. This can create a discrepancy between the supply and demand of nutrified foods and reduce its potential impact on public health. For example, a survey of Kenya found that regardless of the compulsory fortification policy, only 36% of households had access to fortified maize flour [30, 31].

5. Motivators of Nutrified Food Market

Nutrified foods have many opportunities and strategies to overcome challenges and barriers and succeed in the market. Some of the opportunities and strategies are:

5.1. Innovations

Nutrified foods can use the advances in technology and science to develop new methods, processes, and products that can improve their diversity, functionality, and quality. For instance, nanotechnology can create nano-encapsulated nutrients that can improve nutrified foods' delivery, bioavailability, and stability [32-34].

5.2. Differentiation

Nutrified foods can provide superior or unique value propositions that satisfy consumers' expectations, preferences, or needs. For instance, nutrified foods can target niche markets or segments with underserved or unmet nutritional needs, such as children, the elderly, pregnant women, or athletes [35]. They can also tailor or customize their services or products to fit consumers' goals or characteristics, such as their lifestyle, health status, or genetic profile. Social responsibility, credibility, or quality can be identified by enhancing or creating their brand image [36-39].

5.3. Personalization

Nutrified foods can use analytics and data to provide personalized nutrition solutions that suit individual needs, preferences, and behaviour, and improve loyalty and satisfaction. Personalized nutrition depends on various factors, such as diet, food, recipes, nutrition, host, microbiome, and environment, and can be delivered through digital health technologies and the NCP. Personalized nutrition services, especially

those based on nutrigenomics and adiposity markers, are becoming more popular, but still not widespread, in the nutrition industry [40-44].

5.4. Educating Consumers

One of the key strategies to increase the consumption and acceptance of nutrified foods is to educate consumers about their nutritional value and health benefits using various channels, formats, and media. Education can raise consumers' awareness, knowledge, and understanding, affecting their perception, preference, and behaviour towards nutrified foods [45-47]. Figure 5, demonstrates many effective strategies that can be adopted to proliferate consumers sentience.

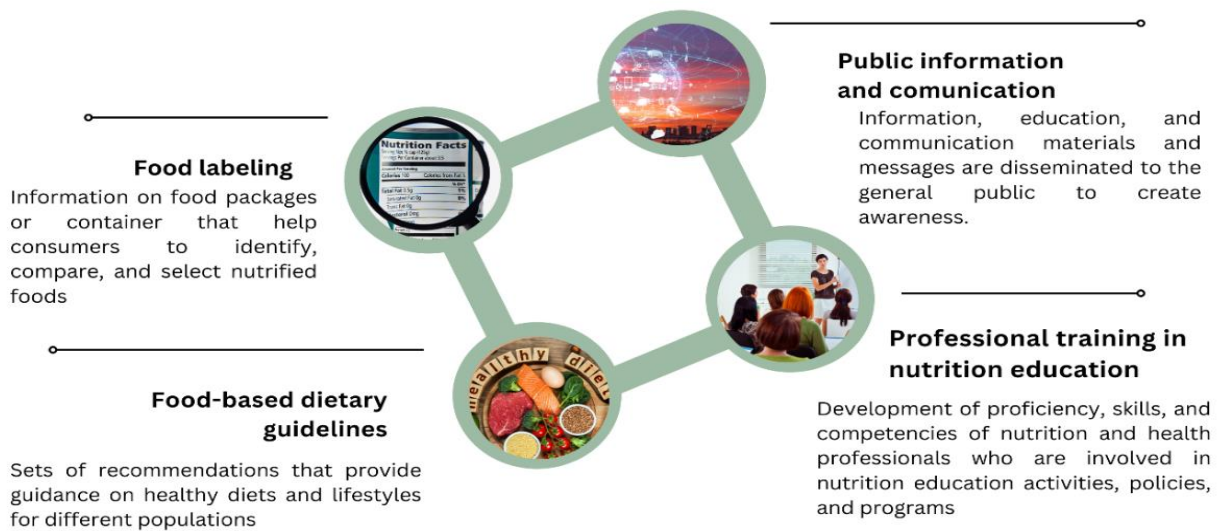


Figure 5 Effective strategies to increase consumer awareness of Nutrified Foods [45-47]

5.5. Balancing Taste and Nutrition

Nutrified foods that boast value-added nutritional or functional properties must strike a balance between taste and nutrition in order to satisfy consumers. However, this can pose a challenge, as certain nutrients may compromise the taste, texture, colour, or smell of foods or require unique methods to maintain their quality. For instance, iron can impart a metallic or bitter taste to foods, omega-3 fatty acids can cause foods to emit a fishy or rancid odour, and probiotics may necessitate refrigeration or fermentation, which can alter their visual or textural properties. Nutrified foods can use a variety of techniques to improve or maximize their nutritional profile and flavour in order to get beyond these obstacles. These tactics include the creation of suitable food matrices or

carriers that either enhance or conceal the flavour or aroma of nutrients or protect them from deterioration or spoiling. Furthermore, natural or synthetic flavourings, sweeteners, or boosters can be added to nutrients to improve or change their flavour or aroma or to satisfy the sensory or hedonistic expectations of the customer [48-50].

5.6. Application of Novel Technologies

Nutrified foods can be improved by regulating the release or delivery of Flavors or nutrients through the use of cutting-edge or unique methods or technology. For example, nano- or micro-sized structures or particles that can encapsulate Flavors or nutrients in nutrified foods at particular locations or times or in response to specific stimuli like enzymes, temperature, or pH can be created using 3D printing, nanotechnology, or microencapsulation. Nutrified foods also contain elements that have been modified through the application of current food biotechnology, fat replacement, enzyme technology, fermentation, and decaffeination. Moreover, nanotechnology and encapsulation are important for safeguarding components and managing their distribution. All these techniques and technologies work synergistically to enhance or create consumers' emotional or sensory experiences [51, 52].

5.7. Safety and Quality Assurance

Nutrified foods must ensure the quality and safety of their platforms, processes, and products using various technologies, tools, and methods, such as certification, tracing, monitoring, and testing. This can prevent the potential hazards and risks of nutrification, such as adulteration, contamination, toxicity, and allergenicity, and ensure nutrified foods' efficacy, reliability, and consistency [53].

5.8. Sustainability and Food Security

Nutrified foods should contribute to society's food security and sustainability, using different indicators, measures, and approaches, such as economic, social, and environmental goals, outcomes, and impacts. This can improve and change the food system and address local and global opportunities and challenges like poverty, malnutrition, population growth, and climate change. For example, a company developed a food ingredient based on microalgae that provides fiber, omega-3, and high-quality protein, using a resource-efficient and low-carbon production process [54-56].

6. Future Perspectives of Nutrified Food

6.1. Technology Integration

Incorporating technology is anticipated to play a critical role in enhancing the accessibility and relevance of personalized nutrition and nutrified food options. Several technologies are poised to significantly impact the future of the nutrified food industry. Digital platforms and apps can facilitate consumers in purchasing nutrified food products, monitoring their health results and food intake, and receiving personalized nutrition guidance [57]. Another example of such technologies is wearable devices and sensors, which can also be utilized to check consumers' metabolic and physiological indicators, such as temperature, heart rate, and glucose levels, and provide feedback and advice on their nutrified food options [58]. Furthermore, the development of smart machines and algorithms that can handle massive data sets and produce the best nutrified food solutions can be greatly aided by machine learning and artificial intelligence technologies [59, 60]. The nutrified food sector is expected to undergo a transformation with the incorporation of these technologies, enabling consumers to access and value nutrified food options and individualized nutrition more than before.

6.1.1. Nanotechnology

Although nanotechnology is not new, the food industry has begun to devote more attention recently because of its several innovative uses and advantages in food processing, packaging, nutrition, and safety. For example, the technology can be applied to distribute and encapsulate nutrients such as vitamin supplements using nano-carriers. The long-term impact of nano-particles in human tissues and any possible safety concerns, when swallowed, still remain ongoing research topics [61, 62].

6.1.2. 3D and 4D Printing of Food

A large number of 3D printers used for food applications are extrusion-based, meaning that a moving nozzle extrudes edible "ink" in a pattern chosen by the 3D model [63]. Additionally, food products can be made more varied and personalized using 3D printing employing co-extrusion printing, which combines many substances, including vitamins and probiotics that are encapsulated. With the increasing popularity of plant-based diets, textures resembling "meat" can be produced using plant-based materials through 3D bio-printing [64]. Four-dimensional food printing, which advances 3D food

printing, is currently being developed. The main uses for 4D printing include modifying food's colour, form, or flavour in reaction to environmental factors like pH, heat, moisture, etc. For example, Ghazal et al. observed colour variations caused by anthocyanins reacting to pH stimuli in a 4D-printed potato-starch meal [61, 65].

6.1.3. Handheld Devices

Compared to laboratory-based testing, food sensing technology on portable analyzers may identify different toxins in food in real time. With point-of-care diagnostics, customers may quickly and easily test their food for particular substances, such as food allergies (like eggs, gluten, or peanuts), on-site. Food allergies are becoming a major public health concern, so these gadgets can also be employed in medical facilities where quick and inexpensive food allergy screening is possible. Given that many people with allergies frequently experience multiple food allergies, various kinds of allergen identification are probably a feature that users of such devices would desire. [66-68].

However, emerging technologies, by definition, come with challenges and opportunities, and a critical understanding is required to balance the benefits with the risks [61].

6.2. Sustainability Focus: Food Security and Environment Protection

The growing demand for sustainable and ethical food practices will shape the future of nutrified food. Consumers will expect more accountability and transparency from nutrified food suppliers and producers and seek products with a positive social and environmental impact. Key sustainability aspects that will influence the future of nutrified food include food waste and loss reduction, greenhouse gas emissions and water footprint reduction, and social and economic development support [69]. Nutrified food products will use new technologies and methods, such as upcycling, bio-preservation, and smart packaging, to reduce food waste and loss along the food supply chain and extend their quality and shelf life [70, 71]. To lower their environmental impact, nutrified food products will utilize alternative protein sources, such as plant-based, insect-based, or cultured meat, that emit fewer greenhouse gases and use less water than animal-based protein [72]. Nutrified food products will also prioritize fair

trade and labour, local and organic farming, and food security and nutrition to support their regions' and communities' social and economic development [73].

6.3. Growth and Diversification Continuation

The nutrified food market is expected to continue growing, with new categories and products emerging to meet the evolving demands of consumers. Various trends and drivers will influence the growth and diversification of the nutrified food market. The growing wellness and health consciousness of customers is one of these factors. Food items with supplementary nutrients will address a range of health objectives and demands, including immune system support, weight control, cognitive function, and athletic performance, as customers look for goods that can improve their overall health and either prevent or treat chronic illnesses [74, 75]. The growing desire for ease and personalization is another motivator. Customers are looking for products that are easy to prepare and consume, fit into their lifestyles and preferences, and offer a variety of ways to consume them and format, such as bars, shakes, powders, and capsules. Nutrified food products will also let consumers choose their Flavors, ingredients, and nutrient levels [76, 77]. Lastly, the growth and diversity of the nutrified food sector will be propelled by the growing demand for unique and unusual ingredients. Nutritious foods, adaptogens, probiotics, and nootropics which provide extra functional and health benefits, will be used in nutrified food products. Customers are eager to try novel and unique substances, particularly those with unusual or exotic origins, benefits, or stories [78].

7. Conclusion

In summary, the food industry is undergoing a significant transformation due to evolving consumer trends and heightened demand for nutrified foods. The increasing popularity of nutrified foods among health-conscious consumers has resulted in a positive perception and a surge in demand, with the market projected to reach billions of dollars in the coming years. Nonetheless, the industry is not without its challenges, and it is prioritizing food technology innovation to combat these challenges. However, it is paramount to consider the safety and effectiveness of nutrified foods, and appropriate methods should be employed to assess their outcomes. The future prospects for the

nutrified food market appear bright, with further innovation and diversification of products on the horizon.

Author Contributions

Conceptualization, F.S, A.G.; validation, S.P, A.S and K.M; writing—original draft preparation, Z.A, S.P, and A.S.; writing—review and editing, F.S, K.M and S.P; visualization, Z.A and A.G.

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Conflicts of Interest

The authors declare no conflict of interest.

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