The Annals of the University Dunarea de Jos of Galati
Fascicle VI – Food Technology (2022), 46(1), 169-183

REVIEW PAPER

DEVELOPMENT OF PLANT BASED FUNCTIONAL FOOD PRODUCTS: A REVIEW

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Received on 15 February 2022
Revised on 24 May 2022

Abstract

The aging population, the increasing prevalence of lifestyle-related diseases, and the need for improved life status have changed attention from only nutrition to a demanding diet maintaining optimal health, opening export opportunities for countries. In response to this demand, companies are developing technologies for processing novel health and wellness products with a globally expanding market. The development and supply of competitive plant-based functional food products, considering consumers' needs and market conditions, accompanied by consumer research as a crucial trigger for the development of these products, will continue to be essential. Multidisciplinary action is crucial for the development of innovative and high-quality functional food products compared to conventional foods, focusing on the maintenance of well-being. Innovation and the introduction of products with well-substantiated health claims are also expected, along with evidence to assist consumers in making the right choice of functional food products to achieve the promised health benefits. Furthermore, the validation of health claims, the discovery of new bioactive compounds, and the development of consumer-focused plant-derived functional products all require continued attention.

Keywords: phytochemicals, functional ingredients, bioactive, plant-based

Introduction

Food is a term that refers to the components that provide energy, ensure the necessary supply of nutrients and support metabolic functions, in addition to the body's growth and maintenance (Kaur and Das, 2011; Zhang *et al*., 2018). Among these, functional foods are designed to have their own health promotion merits and reduce the risk of disease. Transitional health, urbanization and its effects, changing

https://doi.org/10.35219/foodtechnology.2022.1.13

demography with an aging population, food security, the loss of traditional food culture, and awareness of personal health deterioration caused by busy lifestyles with limited options for convenient foods and a competitive food market have all become drivers for the development of functional foods (German, 1999; Kaur and Das, 2011). Consumers are concerned with preventing and minimizing the risk of disease and impairment before they become irreversible and costly to one's quality of life.

Researchers are interested in increased self-medication, increased health authority knowledge, insufficient daily physical activity, media coverage of nutrition and the relationship between diet and health, and scientific advances in nutrition research (German et al., 1999; Kaur and Das, 2011). In response to this need, food firms are creating technologies for processing health and wellness products that will improve their efficacy, increase their potential benefits to customers, and be cost-effective for the industry's survival in a competitive market (Aryee and Boye, 2015). This paper reviews the development of plant-based functional food products.

Overview of Functional Foods and its development principle

Functional foods go beyond providing basic nutrients to provide extra benefits to the customer, such as lowering illness risk and promoting optimal health (Aryee and Boye, 2015). A study comparing the risk of early death caused by inflammation-related health problems found that those who had bad diets were four times more likely to die from gastro-intestinal tract cancers than those who had plant-based diets that were meant to be anti-inflammatory (Aryee and Boye, 2015). A functional food, according to Health Canada (1998), is similar to or may be a conventional food that is consumed as part of a regular diet and has been proven to have physiological benefits and/or reduce the risk of chronic disease beyond basic nutritional functions by possessing bioactive compounds.

Functional foods are defined by the Institute of Medicine's Food and Nutrition Board as any food or food ingredient that may give health benefits in addition to the standard nutrients it provides (Aryee and Boye, 2015). The American Dietetic Association broadens the definition of functional foods by classifying them into four categories. These include traditional, modified, and medical foods, as well as foods for special dietary needs (Aryee and Boye, 2015). Whole foods containing bioactive compounds and polyunsaturated fatty acids, such as garlic, almonds, whole grains, oily salmon, and tomatoes, are examples of conventional foods (Aryee and Boye, 2015). Modified foods are those that have been supplemented, enhanced, or fortified to include bioactive compounds like phytochemicals or other antioxidants to increase health benefits (Aryee and Boye, 2015). Medical foods include lactose-free milk and gluten-free bread, as well as foods for specialized medical uses. Some of these distinctions provide an additional basis for categorizing functional foods. Globally, it is anticipated that 23.6 million people will die from heart disease and stroke by 2030 as the frequency of cardiovascular disease rises (Aryee and Boye, 2015). Despite the widespread use of pharmacological interventions to treat disease and illness, some medications have substantial side effects, and other therapies are ineffective. As a result, many consumers are turning to functional foods containing bioactive components, which have been linked to the treatment and prevention of chronic and metabolic disorders (Houston, 2014).

Functional foods may, in some cases, provide safe and effective solutions for disease prevention and treatment. According to some sources (Aryee and Boye, 2015), plant-based foods have potential health benefits (Table 1). Functional foods are not regulated in most countries, but in others, guidelines have been established on whether a food product can be sold as a food additive, traditional food, or dietary supplement, besides the types of nutrients it contains or health claims that can be made (Aryee and Boye, 2015).

Table 1. Plant based sources of functional foods (Aryee and Boye, 2015).

Categories	**Examples**
Products extracted or purified from plants	• Beta-glucan (e.g., from oats) • Antioxidants (e.g., from blueberries) • Isoflavones (e.g., from soy) • Carotenoids (e.g., from carrots) • Lutein (e.g., from wheat) • Sterols (e.g., from woodpulp) • Essential FAs (e.g., from vegetable oil such as flaxoil) • Soluble fiber (e.g., from fenugreek)
Products ground, dried, powdered, and pressed from plant materials	• Echinacea • Fenugreek • Valerian • Ginseng

Due to the tight laws and regulations established by these agencies to protect consumers from fraudulent claims and to ensure the safe use of these products, the processes leading to the acceptance of the evidence for health claims can be complex and precise (Aryee and Boye, 2015). Based on consumer awareness and knowledge of such claims, marketers may use approved labeling to explain and communicate the favorable health attributes of their products. Plants, animals, and microorganisms, as well as their primary and secondary metabolites, contain bioactive components in functional food products (Aryee and Boye, 2015). These natural food sources could serve as natural replacements for synthetic pharmaceutical products for intervention purposes and to avoid potentially harmful effects from the usage of some pharmaceuticals once the health benefits of these natural food sources are proven. Secondary metabolites such as carotenoids, terpenoids, and alkaloids are created in specialized cell types under certain conditions, whereas primary metabolites such as amino acids, nucleic acids, and fatty acids are essential for normal healthy growth and development (Aryee and Boye, 2015). Some of them are generally recognized as safe, in addition to their role in improving the quality of intestinal microbiota and gastro-intestinal health when consumed (Vasudha and Mishra, 2013). In addition to the potential health benefits, the production of functional foods may aid economic growth and provide a method for some producers to diversify their agricultural and marine-based food products (Aryee and Boye, 2015).

Research and Development of Functional Food-state of the Art

Dairy, bakery, confectionery, soft drinks, and infant foods are among the most popular functional food products (Menrad, 2003; Kotilainen *et al*., 2006). The well-known forms of functional products incorporating plant-based phytochemicals include those that are intended to treat high blood pressure, cholesterol, blood sugar, and osteoporosis (Kaur and Das, 2011).

Functional Foods application in food industry

Functional foods are one of the most promising and rapidly expanding divisions of the food industry. Despite their distribution throughout a wide range of food categories and segments, the market is not uniform, and product preferences may differ between marketplaces (Siró *et al*., 2008).

Fruit based functional foods development targeting the health and wellness market

Although plants provide a substantial number of physiologically active components that are helpful to health, they can also come from animal and microbial sources (Sun-Waterhouse, 2011). According to Vattem *et al*. (2005), Seeram *et al*. (2005), and Scott *et al.* (2008), regular fruit consumption may lower the risk of chronic and infectious diseases, with the health advantages owing mostly to the inherent antioxidants and dietary fiber content of fruits (Sun-Waterhouse, 2011). Consumption of a well-balanced diet, as well as fruits and vegetables, is beneficial to one's health. Fruits are one of the most popular plant-based functional foods for improving overall health and wellbeing, owing to their perceived naturalness and diversified nutrient content (Farajian *et al*., 2010). Fruit and its leftovers, both whole and minimally processed, are naturally healthy items that can be used in smoothies, yoghurts, beverages, and ice creams (Sun-Waterhouse, 2011). The findings of Farajian *et al*. (2010) suggest that the inclusion of dried fruit as a snack prior to a meal can decrease the intake of overall energy and the consumption of dessert. According to Bolton *et al*. (1981), fruit juice with a low fiber content has a less fullness effect after eating than whole fruits, regardless of the caloric level (Sun-Waterhouse, 2011). Natural fruit-based components, natural fruit-derived colorants, fruit fillings, natural fruit sweeteners, and fruit-derived inulin and fructo-oligosaccharide products with a low glycemic index and high soluble solid content are gaining popularity and demand (Sun-Waterhouse, 2011). Fruit pieces can also be utilized as primary or additional ingredients in dishes due to their natural flavor, color, and controlled water activity (Maltini *et al*., 1993). Fruit industry products can be used to recover functional components with a wide range of possible applications and physiological activities (Jiménez-Escrig*et al*., 2001; Leontowicz *et al*., 2001;

Sun-Waterhouse, 2011). Fruit polyphenols have been proven to have anti-ulcer, anti-mutagenic, anti-inflammatory, muscular performance, and immune response effects in addition to anti-neurodegenerative, anti-carcinogenic, antimicrobial, eye health, and visual effects (Lauren *et al*., 2009; Sun-Waterhouse, 2011). Polyphenols and fiber elements that are beneficial to health and disease prevention can be isolated from fruits or their materials and used primarily as fortified or enhanced foods or beverages, as plant phytochemicals (Scott *et al*., 2008; Sun-Waterhouse, 2011). Taking into account the fresh and healthy image of fruits among consumers, functional fruit juices or drinks containing various nutrients and health-promoting bioactive components have been developed (Masibo and Qian, 2009; Adyanthaya *et al*., 2010). Cranberry, blueberry, apple, pomegranate, blackcurrant, acerola, acai, guarana, grapes, mango, bilberries, cherries, strawberries, kiwifruits, feijoa, peach, plums, cranberry, blueberry, and pomegranate are among such fruits out of which functional drinks were developed (Sun-Waterhouse, 2011). Lycopene, known to have preventive effects on oxidative stress, hypertension, diabetes, and atherosclerosis, is a carotenoid antioxidant found in red-colored fruits and vegetables, mainly in tomatoes and tomato-based products (Day *et al*., 2009; Kaur and Das, 2011; Viuda-Martos *et al*., 2014; Eksi *et al*., 2019). A review of epidemiological findings revealed an inverse relationship between tomato and tomato product consumption and the risk of stomach, lung, and prostate cancer, as well as the development of coronary heart disease (Rao *et al*., 2003; Kaur and Das, 2011). Food fortification with lycopene includes dry fermented sausages made by incorporating dried tomato peels into meat, lycopene enrichment of low quality edible oils to induce thermal stability, supercritical fluid encapsulation of lycopene rich tomato pulp waste extract, extruded snacks enriched with barley-tomato pomace blends, and lycopene-soy protein mixture (Kong *et al*., 2010; Kaur and Das, 2011). Total carotene content was enzymatically extracted from carrot pomace and incorporated to develop a functional drink (Stoll *et al*., 2003; Kaur and Das, 2011).

Cereals and cereal components' application in functional foods

Several beneficial effects can be derived from the novel design of consumer-focused cereal food products or their ingredients. Cereals can be utilized as a fermentable substrate for probiotic microorganisms to grow on, as well as a source of non-digestible carbohydrates to increase the growth of lactobacilli and bifidobacteria in the colon (Das and Chakraborty, 2014). Their prebiotic action is due to the presence of water-soluble fibers such as β-glucan and arabinoxylan, oligosaccharides such as galacto- and fructo-oligosaccharides, and resistant starch. Cereal starch can be used as an encapsulation material for probiotics to improve their stability. The development of functional food items is gaining popularity around the world, owing to the market potential of these products (Charalampopoulos *et al*., 2002; Bigliardi and Galati, 2013). Resistant starch found in heated starch and starch-containing cereal food products is among functional fibers that contribute to the fermentable carbohydrates for bacteria in the colon, allowing bowel disease risk reduction (Charalampopoulos *et al*., 2002; Kaur and Das, 2011; Eksi *et al*., 2019). Studies indicated an inverse relationship between whole grains and their dietary fibers and cardiovascular disease and cancer in adults that raised fasting plasmabetaine, which tends to lower LDL cholesterol and fasting homocysteine with the consumption of aleurone rich wheat foods (Kushi *et al*., 1999; Price *et al*., 2010; Kaur and Das, 2011). Marklinder and Lönner (1992) studied and suggested the potential of fermented oatmeal soup (18.5%) containing viable lactic acid bacteria as a base for nutritive solutions in enteral feeding. After testing a number of homo-fermentative and hetero-fermentative probiotic lactobacilli, it was concluded that oats are generally a suitable substrate for lactic acid bacteria growth, regardless of the differences between species and strains (Charalampopoulos *et al*., 2002). The addition of proteases, malted barley flour, and amino acids boosted the rate of pH-decrease and the total amount of lactobacilli in the final product (Marklinder and Lönner, 1994). Bekers *et al*. (2001) investigated that *L. acidophilus* was successfully cultivated in an enzymatically hydrolysed oat mash, reaching a viable cell count of 10^9cfu ml^{-1} (Charalampopoulos *et al*., 2002).

Pulses and pulse components' application in functional foods

Pulses are high in protein, vitamin B, minerals, soluble and insoluble fiber, and starch that digests slowly (Sozer *et al*., 2017; Derbyshire and Delange, 2021). Some of their proteins are sources of bioactive peptides with significant health benefits, such as anticarcinogenic, angiotensin converting enzyme (ACE) inhibitory, hypocholesterolemic, immunomodulatory, and antimicrobial activities (Carbonaro *et al*., 2015), although low digestibility of proteins restricts their use as food and feed for the existence of antinutritional compounds like tannins and phytic acid in the seeds and cell walls (Melito and Tovar, 1995; Sarwar Gilani *et al*., 2012). Pulses have been utilized in pasta and bread for protein fortification, as well as gluten-free dietary ingredients. Bio-processing techniques like fermentation and wet and dry fractionation help to generate new functional pulse ingredients (Sozer *et al*., 2017). Incorporating pulse elements into unique food items necessitates knowledge of their material qualities as well as a conceptual shift within the food business, with a focus on utility rather than purity, especially for protein sources (Boye *et al*., 2010). Pulses will receive more attention and use in the future, especially when combined with cereal basic materials, allowing for novel applications that fulfill customers' sensory and nutritional needs.

Understanding the interaction of food and genes

Proteomics

Proteomics is the study of a proteome as described by a genome on a vast scale (Elliott *et al*., 2007). It investigates the entire set of proteins involved in a species' biological activities (Liu and Qian, 2011). A proteome is the complete set of proteins generated in a biological system at a specific moment and in specific circumstances, representing the expression of a set of specific genes in those circumstances (Trayhurn, 2000). The term "proteome" was coined in late 1994, according to Wilkins *et al*. (1996) and Mann *et al*. (2001), to represent an organism's entire collection of proteins, as well as products originating from actions such as mRNA transcript processing and post-translational alterations. Rather than focusing on the structure and function of a single component, proteomics-based research focuses on the interactions of numerous proteins and their roles as part of a biological system. Cellular proteins play a role in all cellular functions, cell phenotypic development, and tissue or organ development. Under normal physiological conditions and in response to pathophysiological stressors, this phenotype differs (Chang and Huang, 2015). Differences in the environment may alter protein structure and function, leading to the emergence of disease. Proteomic investigation outputs can be used to answer research questions in a variety of biological systems, including human studies, animal models, and cell culture systems (Lam *et al*., 2006; Chang and Huang, 2015).

Other studies into the functions of phytoactive and bioactive components have been undertaken using proteome analysis of food-related products. Proteomics has the significant advantage of measuring the functional products of gene expression and allows the detection of alterations that may be related to protein activation or inactivation by dietary treatments. Indeed, proteome analysis in nutritional research can lead to the discovery of new biomarkers for health and disease diagnosis, as well as the development of new processes by which food components affect health (De Roos, 2008; De Roos and McArdle, 2008). Nutritional proteomics investigates the impact of food components on protein expression and has the potential to identify biomarkers that respond to dietary changes (Fuchs *et al*., 2005; Toldrá and Nollet, 2013). Several cell culture studies using nutritional proteomics have demonstrated the impact of meal ingredients on protein profiles (Wenzel *et al*., 2004). Thanks to advances in proteomic technology, nutritional proteomics has the potential to quickly generate new knowledge suitable for the complex integration of nutrition-protein regulation, discover new biomarkers for nutritional classes, and develop approaches for dietary prevention and disease intervention (Ovesná *et al*., 2008).

Nutrigenomics

Studies on nutrition accounted for the influence of macro or micro nutrients, elaborating physiological needs and determining the meaning of either nutrient shortage or dietary surplus as the main objective. However, it is obvious that nutrient absorption at levels that prevent typical symptoms of nutrient deficiency may be insufficient for long-term health. Because the recommended daily amounts of various nutrients vary and may potentially go the same way, optimal levels are fixed as a new evaluation technique (Ferguson and Fenech, 2012). Nutrigenomics is the study of the effects of specific nutrients or diets on gene expression, whereas genomics is the study of the nucleotide ordering in an organism's genome (Zhang *et al*., 2010). Though nutrigenomics shows how diet affects gene expression, it is most commonly associated with the use of high-throughput genomic technologies in nutrition research (Ferguson and Fenech, 2012). When high-throughput screening is used in nutrition research, it aids in the investigation of how foods affect the expression of the millions of genes that make up the human genome. Nutrigenomics is being increasingly acknowledged as critical for understanding the function of nutrition in maintaining homeostasis, preventing chronic disease risk, and slowing disease development (Ferguson and Fenech, 2012; Ferguson, 2014).

Metabolomics

A comprehensive and quantitative analysis of the full range of metabolites contained inside a biological system is known as a metabolomic analysis (Fiehn, 2001; Hui-Ming and Rowan, 2014). The term "metabolomic analysis" refers to a comprehensive examination of metabolite responses to various environmental conditions (Hui-Ming and Rowan, 2014). It investigates complex organisms' multi-variable metabolic responses to physiological and/or pathological stresses, as well as the resulting disruption of system homeostasis (Nicholson *et al*., 2004). Multiple metabolites in biological samples are determined simultaneously using high-throughput analytical techniques. Metabolomic analysis can be used to identify metabolite biomarkers that indicate a consumer's health condition and disease risk (Hui-Ming and Rowan, 2014). The use of metabolomic techniques to profile food metabolites is not a new concept; before the term metabolomic was coined, chromatography coupled mass spectrometry technologies and high-performance liquid chromatography was used to describe the contents of plant-based diets (Hui-Ming and Rowan, 2014). Metabolomic analysis can be performed on the bioactive parts to identify the present metabolites. To establish chemical identity, segregation of recognized bioactive chemicals may be required (Hui-Ming and Rowan, 2014). The bioactivity of these substances can subsequently be confirmed using *in vitro* or *in vivo* models. Metabolomic analysis can also be used to investigate the link between food bioactivity and the genetic variation of the plants or animals that provide the food (Hui-Ming and Rowan, 2014). Several studies have shown that metabolomic analysis combined with genomic analysis can reveal genetic influences on the control of bioactive or nutritious metabolite levels in the body. Through environmental or genetic manipulation of the plant or animal, this knowledge can be exploited to maximize food ingredients. Metabolomic analysis can also be used to determine the effects of different genotypes on food absorption and metabolism (Polanski and Kimmel, 2010; Hui-Ming and Rowan, 2014).

Bioinformatics

Bioinformatics is a subject that was created with the goal of bringing order to the vast data volumes generated by new molecular biology technology. Large-scale DNA sequencing necessitated the development of tools for sequence assembly and annotation, which led to the development of these methodologies (Polanski and Kimmel, 2010). The examination of various gene expressions using diverse physical mediums is another novel technology that has begun to provide a wealth of new data. The concept is to expose a sample of coding DNA extracted from a target specimen to a DNA chip containing thousands of DNA nucleotide sequences, each uniquely identifying a gene. Multiple gene expression approaches are frequently used to identify subsets of genes that distinguish between two or more biological states, resulting in sample and gene classification. Existing computational approaches with their origins in computer science and statistical origins, such as principal component analysis and analysis of variance, have been modified together with the investigation of novel methods as a result of the analysis of gene expression data (Polanski and Kimmel, 2010).

Functional food product design, product development principles and regulations

The integration of certain bioactive ingredients with favorable physiological advantages is referred to as "functional food development" (Hamer *et al.*, 2005; Smith and Charter, 2010). By incorporating bioactive substances into food ingredients, various technological strategies can be used to improve health development (Duchateau and Klaffke, 2009; Smith and Charter, 2010). Another strategy relies on the proper selection of dietary components and their relative quantities, as well as the utilization of non-calorie components and the retention of a considerable amount of water (Zuniga and Aguilera, 2008; Smith and Charter, 2010). Aside from the importance of food's health effects, flavor, new textures, and convenience remain important factors for consumers (Smith and Charter, 2010). The rational design and production of functional foods will be aided by a better understanding of the molecular, physicochemical, and physiological processes that occur during food intake, digestion, and absorption. This will improve health and wellness (McClements *et al.*, 2008). More research is required to understand the link between the bioavailability of functional substances and food microstructure. Furthermore, despite the necessity to manufacture functional food for health reasons, it will be critical to meet customer needs for healthy food products without sacrificing the delight and pleasure of eating (Wansink, 2007). As a result, the food industry must focus on introducing advancements in health, texture, nutrition, and targeted delivery solutions to fulfill market and customer expectations (Berry, 2008). Another area of focus during the creation of food items is the regulation of functional foods.

Most jurisdictions use product categories like food and drugs to standardize consumer products (Siró *et al.*, 2008). Within the regulatory category, specific divisions are tasked with the assessment and regulation of each product type. This highly organized and hierarchical framework has long served as the gold standard for consumer product regulation. This framework is sufficient for the vast majority of products that can be clearly identified and specified. In general, debates over the regulation of functional foods in a specific country focus on the structure in place in that jurisdiction to allow claims for similar goods (Vapnek and Spreij, 2005).

Trend and perspectives in manufacturing of functional food industry in developing countries

The food industry is one of the most essential industries, as it is responsible for the processing of agricultural raw resources and the provision of food, both of which are crucial for employment and economic output (Menrad, 2004; Kotilainen *et al.*, 2006). Consumer demands in food production have shifted dramatically as people began to believe that foods, in addition to meeting nutritional needs, had a direct impact on their health (Mollet and Rowland, 2002). Technical and economic changes in society, as well as in manufacturing and food processing, have had a significant impact on the entire food supply chain up to the distribution of food to end consumers, forcing companies to focus on functional food products that meet consumers' demand for a healthy lifestyle (Kotilainen *et al*., 2006). New scientific and technical approaches to food processing, as well as the introduction of novel foods, are among the most recent innovations in the food industry, with functional foods playing a prominent role, as evidenced by increasing demand for improved quality of life and rising health-care costs (Kotilainen *et al*., 2006). This caused interest in functional food product investigations and innovation in the food industry (Kotilainen *et al*., 2006; Annunziata and Vecchio, 2011).

There has been an increase in demand for new functional food products as the marketplace has become more globalized, particularly in the food sector (Kotilainen *et al*., 2006). Traditional wisdom has historically been valued in Africa, Southeast Asia, and Latin America, with extensive knowledge of the functional, preventative, and even curative aspects of various foods. As a result, the concept of functional foods as health-promoting foods is widely accepted and welcomed. The demand for functional foods in underdeveloped nations is small but expanding, providing an opportunity to build local marketplaces to meet it (Kotilainen *et al*., 2006). However, high prices of functional food products in underdeveloped countries, such as Africa, tend to exclude low-income people who could benefit the most from the products. In more established markets, the functional food business has commercial export prospects in functional ingredients, value-added raw materials, and even consumer products (Kotilainen *et al*., 2006). Underdeveloped infrastructure, an unorganized and fragmented retail network, a lack of research facilities and little collaboration between academic research and the industry, a focus on bulk commodities with low processing levels, high ingredient costs, and high costs in meeting food safety and quality regulations are all suggested as key concerns that require attention and empowerment. The government's responses to these issues, as well as international organizations and the private sector's reactions and facilitation of the process, will determine the future of functional food product markets (Kotilainen *et al*., 2006).

Conclusions

In epidemiological and clinical research, consumption of specific types of functional foods has been found to have neutral or beneficial impacts on health, wellness, and the decrease of risk factors for certain diseases. Consumers who are health-conscious have become more aware of these plant-based products and have a more favorable opinion of them. The development of functional food items appears to have market potential, but research outputs are needed to support private investments, consumption decisions, and government regulations. Because of the growing industry, efforts are being made all over the world to develop novel plant-based functional foods. Despite the fact that tremendous progress has been made in the food production and market sectors, there is still a lot of room for more study and development.

To meet the increased demand for health-promoting foods in developing nations, multidisciplinary efforts are needed to create and discover plant-based functional food items with higher quality requirements than conventional products aimed at maintaining health. Investing in the sector of functional foods can only be worthwhile if particular regulations, an international collaborative approach, and a direct and successful plan for producer-consumer contact are adopted. Despite the enormous success made so far in the functional food products market, there is still a lot of room for more research and development. The development of consumer-focused shelf-stable, tasty, and convenient plant-based functional food products, as well as the validation of health claims, the identification of new bioactive, well-developed processing technologies, and the development of consumer-focused shelf-stable, tasty, and convenient plant-based functional food products, all require continued attention. As a result, expect more innovation and the introduction of products with well-supported health claims. More data and proof must be provided to help consumers make the best decisions about which functional foods to buy and how to use them to get the health benefits they claim.

Acknowledgements

The authors acknowledge Addis Ababa University for availing Urkund plagiarism checker software.

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