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Unlocking the full potential of functional beverages in medicinal and aromatic plants

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Abstract

The rise of emerging diseases and shifting lifestyles have heightened the demand for functional foods and beverages, which offer health benefits beyond basic nutrition. Functional Beverages (FBs) have become pivotal in meeting these needs due to their health advantages and sensory appeal. With consumers seeking improved quality, safety, and functionality in beverages, the industry is prioritizing enhancements in production processes, sensory properties, and health-promoting effects. Herbal infusions and plant-based beverages, devoid of harmful heavy metals, are perceived as safe FBs, driving their anticipated market growth. Key medicinal and aromatic plants (MAPs) such as peppermint, rosemary, and ginger are extensively utilized in FBs, highlighting their significance. Incorporating extracts of elderflower, ginger, and hibiscus into fruit juices enhances their naturalness and health benefits without altering taste or color. Popular herbal infusions include chamomile, ginger, and peppermint teas, reflecting consumer preferences. However, careful consideration and regulatory oversight are crucial when introducing new flavorings into beverage production to mitigate potential health risks. A systematic approach to incorporating MAPs into FBs is crucial for ensuring population health and safety.

1. Introduction

In recent times, the food and beverage sector has experienced a profound evolution, propelled by the convergence of emerging health concerns and shifting social lifestyles. With the emergence of the COVID-19 pandemic, there is a notable inclination among people towards adopting novel dietary choices and being receptive to trying different food variants that promote their health (Rizwana *et al.,* 2021). Furthermore, the indiscriminate usage of modern medicines, including antibiotics and steroids, has contributed significantly to this inclination towards natural remedies. This preference for natural remedies has fueled the rapid expansion of plant-based drugs, pharmaceuticals, functional foods, nutraceuticals, and even cosmeceuticals.This transformation has led to a significant increase in the demand for functional foods, signaling a pivotal shift where consumers increasingly look for more than just basic nourishment from their food choices (Giri *et al.,* 2023; Grumezescu and Holban, 2019). Medicinal and aromatic crops facilitate change by fostering a shift towards healthier dietary habits and lifestyles. Their incorporation into functional foods encourages consumers to prioritize wellness, promoting a more proactive approach to health management. Additionally, their sustainable cultivation practices contribute to environmental conservation, aligning with growing societal concerns about ecological responsibility. Embracing these crops signifies a fundamental change in how we perceive and interact with food, highlighting the interconnectedness between personal health, environmental sustainability, and societal well-being. This review article aims to examine the important role that FBs play in meeting the unique needs and preferences of today's consumers. By highlighting how these products are carefully designed to promote well-being and appeal to the changing tastes of modern consumers, this review seeks to offer a thorough understanding of the diverse world of functional foods and beverages.

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2. Functional beverages

FBs comprise a wide range of non-alcoholic drinks aimed at delivering targeted health benefits beyond simple hydration. Through the utilization of nutrients and bioactive compounds, these beverages offer a comprehensive approach to promoting wellness, customized to meet the varied needs and desires of consumers (Tolun and Altintas, 2019). FBs offer a wide range of benefits (Figure 1) that makes them as an optimal medium for delivering health-enhancing compounds: Firstly, they can be customized to meet specific demands regarding container contents, size, shape, and appearance, thereby enhancing their attractiveness to consumers. Additionally, beverages are convenient to distribute and store, requiring minimal refrigeration, which contributes to their accessibility and widespread availability. Moreover, their affordability compared to other food products makes them a practical choice for many consumers. Furthermore, beverages can easily incorporate desirable nutrients and bioactive compounds, providing added health benefits beyond basic hydration. Overall, beverages serve as versatile and convenient options that address various consumer demands while offering the potential for improved health and well-being (Giri *et al.,* 2023).

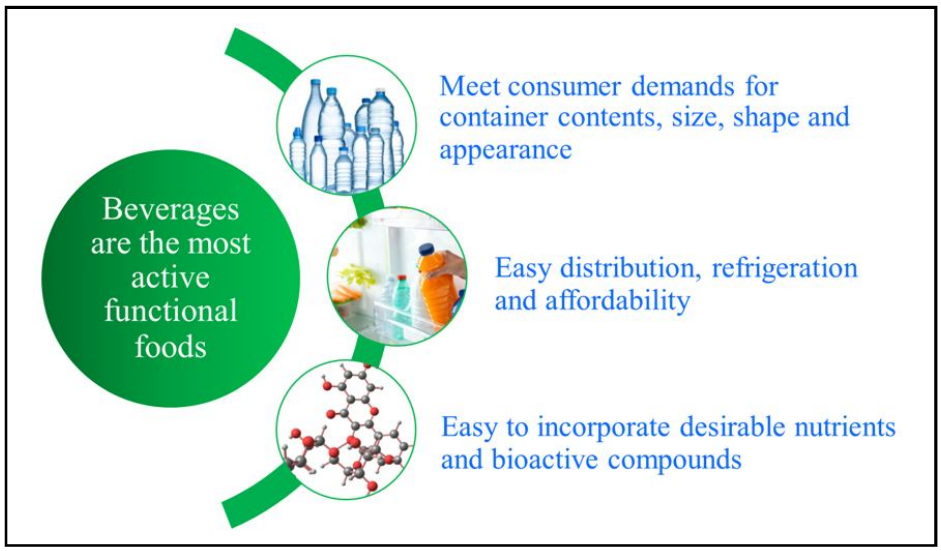

Figure 1: Advantages of functional beverages.

2.1 Key nutrients and bioactive molecules in functional beverages

FBs are nutrient-rich reservoirs containing vital compounds for overall health. They provide essential vitamins like C, D, and B complex, along with minerals such as calcium and magnesium crucial for bone and muscle health. Antioxidants like polyphenols from fruits and vegetables offer anti-inflammatory and cardiovascular benefits, while plant pigments provide vibrant colors and additional antioxidant properties. Phytosterols aid in lowering LDL cholesterol levels and reducing heart disease risk. Essential fatty acids like omega-3 support brain function and heart health, while fiber aids in digestion and weight management. Prebiotics and probiotics promote gut health and strengthen the immune system. These beverages offer a convenient and effective way to incorporate essential nutrients and bioactive compounds into daily diets, promoting overall well-being (Sharma and Sarwat, 2022).

2.2 Major categories of functional beverage products

FBs are categorized into various groups, each offering distinct characteristics and nutritional compositions to suit the diverse needs and preferences of consumers. The major categories of functional beverages include dairy-based, vegetable and fruit, cereal-based, and sports and energy drinks. Dairy-based options like fresh milk and drinkable yogurt offer rich sources of nutrients like calcium, vitamins A, D, and B12, promoting overall health. Vegetable and fruit beverages provide a refreshing alternative, supplying antioxidants, fiber, and vitamins suitable for those with dairy allergies. Cereal-based drinks, crafted from grains like rice and barley, offer convenience and nutrition, packed with antioxidants and fiber to support gut health and overall wellness. Lastly, sports and energy drinks serve specific purposes like sports beverages prevent dehydration during physical activity by supplying essential carbohydrates, electrolytes, and vitamins (*e.g.,* powerade, accelerade), while energy drinks deliver rapid energy and cognitive enhancement through ingredients like sugar and herbal extracts (*e.g.,* red bull, monster energy). Each category offers a variety of options to complement health and lifestyle choices (Chaudhary, 2019; Pérez-Rodríguez *et al.,* 2023).

2.3 Functional beverages market

The FBs market, a swiftly growing segment within the broader functional food sector, sees the sports and energy drink category holding the largest market share, responding to consumer demand for performance-enhancing products. North America leads, fueled by the popularity of plant-based beverages among health-conscious consumers, while the Asia-Pacific region shows promise due to the widespread use of e-commerce platforms for accessing functional beverages. Global growth in the FBs market (Figure 2) has been remarkable, reaching $128.1 billion USD in 2022. Forecasts anticipate continued expansion, with the market projected to reach $205.8 billion USD by 2032, representing a Compound Annual Growth Rate (CAGR) of around 4.8%. This growth mirrors rising consumer interest in beverages offering health benefits beyond hydration and nutrition, driven by factors like increasing health awareness, lifestyle shifts, and advancements in product formulations (Gupta *et al.,* 2023).The Indian market for functional beverages holds substantial significance due to a confluence of factors. With a rapidly growing population, increasing urbanization, and rising disposable incomes, there's a notable shift towards healthier consumption patterns. This trend is further fueled by a heightened awareness of health and wellness, prompting a demand for beverages offering added nutritional benefits. India's diverse cultural heritage and traditional medicinal practices also provide a fertile ground for the development of functional beverages tailored to regional tastes and preferences, incorporating ingredients known for their health-promoting properties. Overall, the Indian market presents immense potential for the functional beverage industry, driven by evolving consumer preferences, health consciousness, and accessibility. As the market progresses, manufacturers are expected to emphasize innovation, product diversification, and strategic collaborations to seize emerging opportunities and satisfy the diverse preferences of consumers worldwide.

3. Potential of medicinal and aromatic plants in the functional beverage production

MAPs have long been valued for their therapeutic properties, utilized to prevent and treat various health conditions due to their diverse

biological effects that benefit human health. These plants contain bioactive molecules (BAMs) with unique chemical compositions, aromas, flavors, and health-promoting properties (Manousi *et al.,* 2019). With increasing consumer demand for FBs that offer both sensory enjoyment and health benefits, the FBs industry is focusing on improving beverage quality, safety, and functional attributes. This collective effort aims to enhance the overall sensory experience for consumers while supporting their health and nutritional needs. Herbal infusions and plant-based beverages are emerging as safe options within the FBs market, poised for significant growth as consumers prioritize wellness and seek natural, plant-derived alternatives. The future direction of the FBs industry is expected to be shaped by ongoing exploration and utilization of MAPs and their BAMs (Etheridge and Derbyshire, 2020).

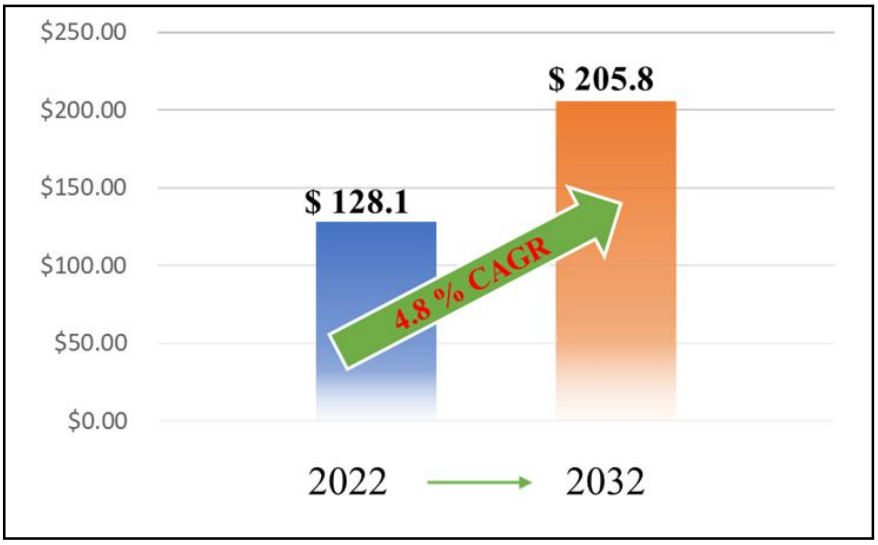

Figure 2: Projected global growth in the functional beverages market (Billion USD).

Meanwhile, the global market for plant-based beverages has witnessed impressive growth recently, reflecting a shift in consumer preferences toward healthier and more sustainable beverage options (Dimitrova and Ilieva, 2023). In 2022, the plant-based beverages market (Figure 3) reached a notable milestone, reaching a size of USD 27.90 billion. Estimates indicate continued growth, with the market expected to reach USD 73.19 billion by 2032, with a CAGR of 10.12% (Prakash *et al.,* 2023). This growth underscores the strong global demand for plant-based beverages, driven by factors such as increasing health awareness, environmental concerns, and a growing vegan population. As consumers seek alternatives to traditional dairy products and embrace plant-based diets, the plant-based beverages market is poised for sustained expansion, offering ample opportunities for innovation, diversification, and market growth (Khalaf *et al.,* 2021).

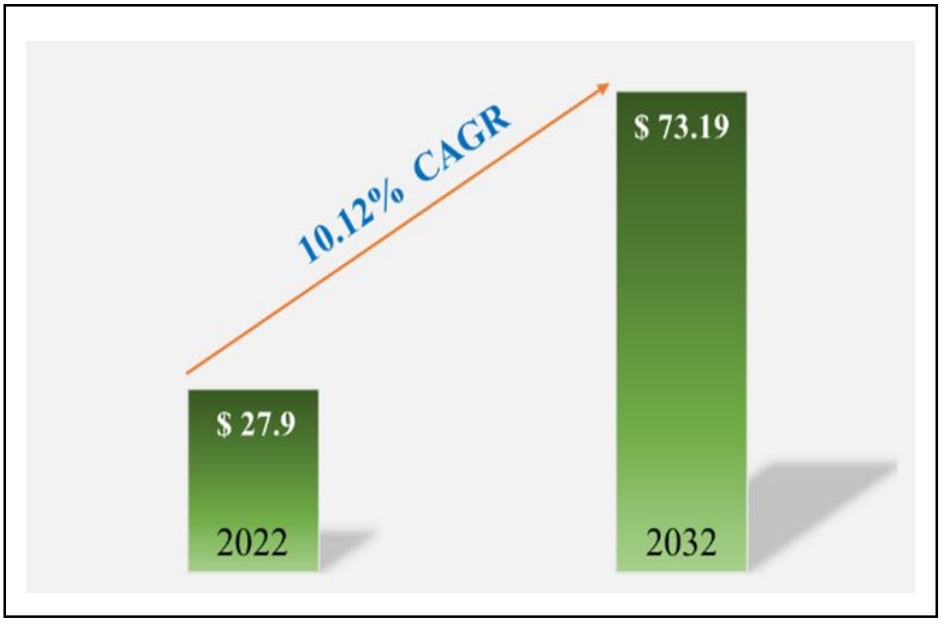

Figure 3: Projected plant-based beverages global market (Billion USD).

4. Improvements in functional beverages with medicinal and aromatic plants

The integration of MAPs into FBs production has sparked advancements in beverage formulation and manufacturing methods. This includes fortifying existing beverage recipes by incorporating MAP-derived components such as plant extracts (PEs) and essential oils (EOs), amplifying nutritional content, flavor profiles, and health benefits. Moreover, there's a drive towards developing novel formulations that leverage the bioactive compounds found in MAPs, yielding beverages with both functional and sensory appeal. To ensure product quality and safety while maximizing bioactive compound content, both nonfermentative and fermentative processes are being employed in extraction and preservation techniques. Additionally, encapsulation methods, including cutting-edge nanotechnology, are being utilized to maintain the stability, activity, and bioavailability of MAP-derived bioactives, thus enhancing their efficacy and consumer benefits. Responding to the growing demand for healthier alternatives, natural sweeteners sourced from MAPs or other origins are being incorporated to reduce overall sugar content without compromising taste or palatability. These advancements underscore a dynamic landscape where science, innovation, and consumer preferences converge to shape the future of functional beverages enriched with the goodness of MAPs.

These progressive strategies reflect a transformative shift in beverage manufacturing towards creating FBs that not only meet consumer preferences but also promote health and wellness through the inclusion of beneficial compounds from MAPs (Maleš *et al.,* 2022; Sayas-Barberá *et al.,* 2023). Recent trends in the functional beverage industry highlight a significant focus on fortifying yogurt and fermented milk drinks with BAMs sourced from various MAPs, aiming to enhance their nutritional value and health benefits. Additionally, there's a growing utilization of PEs and EOs to enrich fruit juices and dairy products, ensuring added health-promoting properties while maintaining sensory appeal (Eksi *et al.,* 2019). A list of commonly employed MAPs utilized in the creation of FBs is provided in Figure 4, alongside their respective biological attributes in Table 1.

Figure 4: The most commonly utilized medicinal and aromatic plants in the functional beverages industry.

5. Incorporating plant extracts for enhanced functional beverages

PEs play a fundamental role in the creation of functional beverages, deriving benefits from botanical sources (Chang *et al.,* 2020). Available in various forms like liquid concentrates, solid powders, or viscous substances, they enrich beverages with enhanced nutritional content and health-promoting properties. PEs are utilized in FB production through two main methods, *viz*., enhancing existing beverage formulations and innovating novel formulations (Finimundy *et al.,* 2020). Through synergistic combinations with other botanical ingredients, PEs open up a range of possibilities, resulting in beverages that not only excite taste buds but also nourish and energize the body (Hafeez *et al.,* 2023).

Innovative blends, such as lemonade infused with ginger and mint extracts, exemplify the transformative potential of PEs in functional beverage production. Similarly, the fusion of lemongrass and lemon juice not only imparts a refreshing zest but also offers relief from common ailments such as insomnia and anxiety, underscoring the

potential synergies in addressing specific health concerns. Pairing black tea with complementary extracts like black pepper, ginger, and basil not only enhances the beverage's antioxidant potency but also promotes digestive wellness. Moreover, combinations like sea lavender with green tea showcase the diverse health benefits of synergistic blends, ranging from antioxidative protection against oxidative stress to mitigating the risk of neurodegenerative diseases, showcasing the multiple advantages of incorporating PEs into beverage formulations (Hernández-Rodríguez *et al.,* 2019; Tamer *et al.,* 2019).

Table 1: Commonly utilized medicinal and aromatic plants in functional beverages production and their associated biological properties

S. No.	Scientific name	Common name	Major bioactive compounds	Biological properties	Commercial FB product	References
1.	*Artemisia absinthium* L.	Wormwood	Thujyl alcohol esters, Á/β-thujone, camphene, quercetin, kaempferol.	Antimicrobial, antiprotozoal, antihelmintic, hepatoprotective, antiulcer, cytotoxic, analgesic, hepatoprotective.	Artemis herbal Beverage	Batiha *et al.* (2020); Szopa *et al.* (2020)
2.	*Cymbopogon citratus* Stapf.	Lemongrass	Citral, geraniol, neral, citronellol, luteolin.	Antihelmintic, anti-inflammatory, antioxidant, antimicrobial, antihelmintic, anxiolytic, hepatoprotective.	Lemongrass tea	Boeira *et al.* (2020); Mahar *et al.* (2022)
3.	*Lavandula angustifolia* Mill.	Lavander	Linalool, linalyl acetate, 1, 8-cineole, lavandulol, rosmarinic acid, terpinene-4-ol.	Anxiolytic, antidepressant, sedative, antimicrobial.	Lavender herbal infusion tea	Firoozeei *et al.* (2021); Lari *et al.* (2020)
4.	*Matricaria recutita* L.	German chamomile	Chamazulene, α-bisabolol and its oxides., chamazulene, quercetin.	Antimicrobial, antioxidant, anticancer, anti-inflammatory, sedative, anxiolytic, antihyperglycemic, antiseptic.	Chamomile flower extract infusion	Hajizadeh-Sharafabad *et al.* (2020); Mailänder *et al.* (2022)
5.	*Melissa officinalis* L.	Lemon balm	Geranial, neral, citronellal, thymol, β-caryophyllene.	Anxiolytic, antidepressant, anti-insomnia, anti-Alzheimer, antispasmodic, antifungal, antibacterial, antihypertensive.	Lemon balm tea and health drinks	Draginic *et al.* (2022); Petrisor *et al.* (2022)
6.	*Mentha piperita* L.	Peppermint	Menthol, menthone, menthyl acetate, isomenthone.	Anti-inflammatory, antimicrobial, antiviral, antimicrobial, antioxidant.	Pepper mint tea and leaf powder	Gholamipourfard *et al.* (2021); Wei *et al.* (2023)
7.	*Rosmarinus officinalis* L.	Rosemary	1,8-cineole, camphor, Á-pinene, rosmanol, Rosmarinic acid, quercetin.	Antimicrobial, anxiolytic, anti-inflammatory, anticancer, neuroprotective, antidepressant, immunomodulatory.	Rosemary functional drinks and blends	Christopoulou *et al.* (2021); Rahbardar and Hosseinzadeh (2020)
8.	*Salvia officinalis* L.	Dalmatian sage	Á/β-thujones, camphor, 1, 8-cineole, camphor.	Anti-Alzheimer, antimicrobial, antioxidant, antimicrobial, memory improvement, antidiabetic.	Sage herbal extracts	Mot *et al.* (2022); Uþã *et al.* (2021)

9.	*Thymus vulgaris* L.	Thyme	Thymol, carvacrol, p-cymene, α-terpineol, linalool, geraniol, rosmarinic acid.	Antimicrobial, antimicrobial, fungicidal, antiviral, antioxidant, anti-inflammatory, anti-spasmodic, anti-acne.	Thyme energy drink and tea	Patil *et al.* (2021); Silva *et al.* (2021)
10.	*Zingiber officinale* Rosc.	Ginger	Gingerols, shogaols, paradols.	Antioxidant, antimicrobial antidiabetic, antiobesity, antinausea.	Ginger tea and infused drinks	Duraisami *et al.* (2021); Rani *et al.* (2023)

Among the popular herbal infusions, Chamomile (*M. chamomilla*), Ginger (*Z. officinale*), Lemon balm (*M. officinalis*), Peppermint (*M. piperita*), Rosehip (*Rosa canina*), and Spearmint (*Mentha spicata*) stand out for their wide consumption and recognized health benefits (Etheridge and Derbyshire, 2020). Each of these herbs brings a unique flavor profile and a diverse range of health benefits, making them favored choices for brewing herbal teas and infusions. From the soothing properties of chamomile to the refreshing taste of peppermint, each herb offers a distinct experience, appealing to a broad spectrum of tastes and preferences (Gholamipourfard *et al.,* 2021).

In addition to enhancing the functional properties of functional beverages, PEs also contribute to elevating the sensory experience of consumers. Incorporating extracts from botanical sources such as elderflower, ginger, and hibiscus into fruit juices subtly enhances their nutritional value and consumer appeal without compromising familiar taste or vibrant color (Jakubczyk *et al.,* 2022). This aligns with the growing consumer preference for clean-label products made from wholesome, minimally processed ingredients, thereby enhancing the perceived quality and authenticity of the beverages. In essence, PEs serve as indispensable ingredients in the development of functional beverages, offering a multitude of benefits ranging from enhanced nutrition to improved sensory experiences. As the demand for FBs continues to rise, PEs are poised to play an increasingly significant role in shaping the landscape of the beverage industry, meeting the diverse needs and preferences of consumers worldwide.

6. Incorporation of essential oils in functional beverage production

EOs are pivotal in crafting premium functional beverages, revered for their diverse flavors, captivating aromas, and therapeutic benefits. EOs such as orange, lime, lemon, lavender, rosemary, geranium, and citronella oil hold profound significance in the beverage industry, offering diverse attributes that enrich formulations. Noteworthy, compounds like citral and menthol contribute refreshing and invigorating sensations (Jugreet *et al.,* 2020), while citrus EOs, notably derived from lemon or lime, play a crucial role in enhancing flavor profiles, particularly in the soft drink sector.

EOs extracted from various plants, including Cinnamon (*Cinnamomum verum*), Coriander (*Coriandrum sativum*), Lemon (*Citrus limon*), Lime (*Citrus limetta*), Neroli (*Citrus aurantium*), Nutmeg (*Myristica fragrans*), Orange (*Citrus sinensis*), and Vanilla (*Vanilla planifolia*) serve as premium flavor enhancers, enhancing the taste experience of beverages (Barbieri and Borsotto, 2018). Whether it is the warm and spicy notes of cinnamon, the fresh citrus aroma of lemon and lime, or the sweet and floral fragrance of neroli, these EOs contribute to creating beverages with rich and enticing flavor profiles. Incorporating EOs into beverage formulations elevates their sophistication and sensory appeal, meeting the discerning demands of today's consumers.

Moreover, the therapeutic properties inherent in EOs add another dimension to their utility in FB production. Lavender oil, renowned for its calming and relaxing effects, finds application in beverages aimed at promoting stress relief and relaxation, while rosemary oil, with its stimulating and energizing properties, enhances beverages designed to boost energy and mental clarity. Similarly, geranium oil and citronella oil, celebrated for their antibacterial and insect-repelling properties, lend a unique functional aspect to beverages, aligning with consumer preferences for products that offer holistic health benefits (Ameh and Obodozie-Ofoegbu, 2016; Ni *et al.,* 2021).

7. Nanoencapsulation

Nanoencapsulation, a cutting-edge technology, is revolutionizing the functional beverage industry by offering innovative solutions for enhancing bioavailability, stability, and targeted delivery of bioactive compounds derived from MAPs. It involves encapsulating these compounds in nano-sized carriers to protect them from degradation and ensure efficient absorption. Controlled release optimizes therapeutic effects. Additionally, hydrophobic compounds like essential oils can be incorporated into aqueous-based beverages without compromising solubility or sensory attributes. Nanocarriers improve dispersion, preventing phase separation and maintaining product homogeneity. This enables development of clear, stable, visually appealing beverages with enhanced bioactive content, offering consumers a more enjoyable experience (Silva *et al.,* 2019).

Nanoencapsulation allows targeted delivery of bioactive compounds, enhancing their effectiveness in functional beverages. By encapsulating MAP-derived bioactives, beverages can offer specific health benefits like antioxidants and immune support. This precise delivery system maximizes therapeutic potential and enables personalized nutrition tailored to individual needs. Nanoencapsulation advances functional beverages, meeting the demands of health-conscious consumers.

Nanoencapsulation of EOs is an innovative technique gaining traction in the food and beverage industry, offering several advantages for improving product quality and efficacy. One notable benefit is its ability to minimize the impact on the sensory properties of foods and beverages. By encapsulating EOs at the nano-level, unwanted flavors or aromas associated with certain oils can be reduced, resulting in a more subtle and controlled release of aromatic compounds (Maurya *et al.,* 2021). Additionally, nano-encapsulation acts as a

protective barrier for EOs, safeguarding them from degradation and ensuring their stability and effectiveness over time. This protective layer shields the volatile components of EOs from environmental factors such as light, oxygen, and temperature fluctuations, thereby preserving their sensory and functional properties (Silva *et al.,* 2019).

Furthermore, nanoencapsulation extends the release of BAMs contained within EOs, facilitating a gradual and controlled delivery of these beneficial compounds. As a result, this sustained release mechanism enhances the overall impact of EOs on taste, aroma, and potential health benefits for an extended duration (Rathee *et al.,* 2021).

8. The regulatory framework for functional beverages

FBs are governed by diverse regulatory frameworks worldwide, aiming at ensuring consumer safety, product quality, and accurate labeling. Regulations encompass food safety standards like good manufacturing practices (GMP) and hazard analysis and critical control points (HACCP), preventing contamination and hazards. Ingredient approval involves using only authorized additives and adhering to specified levels. Labeling requirements mandate transparent display of ingredients, nutrition, and health claims for informed consumer choices. Health and nutrient content claims require scientific substantiation and approval. Quality standards ensure consistency and authenticity, covering composition and processing methods. Some jurisdictions demand product registration or pre-market approval, involving rigorous evaluation. Regulatory agencies enforce compliance through monitoring, sampling, and enforcement actions, ensuring adherence to standards. International efforts for harmonization aim at streamlining regulations across borders. Ultimately, compliance is vital for FB manufacturers to access markets, uphold consumer trust, and mitigate risks (Cong *et al.,* 2020; Corbo *et al.,* 2014).

9. Toxicological and metabolic evaluations of functional beverages

Toxicological and metabolic evaluations of functional beverages are crucial steps in ensuring their safety and efficacy for consumer consumption. These evaluations typically involve comprehensive assessments of the ingredients used in the beverages, as well as their potential interactions and effects on human health. Toxicological evaluations focus on identifying any potential harmful effects of the ingredients or additives present in functional beverages. This includes assessing the acute and chronic toxicity levels, as well as evaluating the potential for allergic reactions or adverse effects in sensitive populations. Various toxicological studies, such as animal testing and in vitro assays, may be conducted to determine the safety profile of the beverages (Ribnicky *et al.,* 2004).

Metabolic evaluations, on the other hand, examine how the body processes and utilizes the nutrients and bioactive compounds present in functional beverages. This involves studying the absorption, distribution, metabolism, and excretion of these compounds in humans through pharmacokinetic studies and metabolic profiling. Understanding the metabolic fate of these compounds is essential for assessing their bioavailability and potential health benefits. Overall, toxicological and metabolic evaluations play a critical role in ensuring the safety, quality, and efficacy of functional beverages, providing consumers with confidence in their consumption choices and regulatory agencies with the necessary data for establishing guidelines and regulations (Žuntar *et al.,* 2020).

10. Medicinal and aromatic plants based functional beverages in market

Several successful and famous examples of MAP-based functional beverages abound in the market, each leveraging the health-promoting properties of MAPs. Ayurvedic herbal teas, such as those offered by Yogi tea and traditional medicinals, feature ingredients like turmeric, ginger, and holy basil, renowned for their wellness benefits according to Ayurvedic traditions. *Aloe vera* drinks, produced by brands like ALO drink and Lily of the desert, are celebrated for their hydration and digestive support properties. Green tea-infused beverages from Honest tea and Ito enharness the antioxidant power of green tea, often combined with other MAPs for enhanced flavor and health benefits. Elderberry-based drinks, like those from Sambucol and Gaia herbs, are valued for their immune support attributes, while chamomile-infused beverages, such as those by Celestial seasonings, offer relaxation and anti-inflammatory benefits. These examples underscore the market's embrace of MAP-derived functional beverages, providing consumers with a diverse array of flavorful options that promote holistic well-being (Suna *et al.,* 2019).

11. Constraints

Developing FBs with PEs requires meticulous control and traceability at every production stage. Factors such as plant species sourcing and extraction parameters must be finely tuned to preserve bioactive compounds' integrity. Accurate identification and quantification of these compounds ensure product consistency and potency. Attention to sensory attributes like taste and aroma is essential for consumer acceptability. Optimal dosage and careful selection of EOs are crucial for delivering health benefits without adverse effects. Managing variations in EO chemical composition and addressing negative sensory effects require strategic selection and concentration adjustment. Overall, success depends on a thorough understanding of extraction techniques, chemical compositions, and sensory attributes (Eksi *et al.,* 2019; Guiné *et al.,* 2020).

12. Future prospects

The future of FBs is promising as consumer health awareness grows. Demand for products offering both nutrition and functional benefits is rising, driving innovation. As consumers become more environmentally conscious, they seek products that are not only good for their health but also for the planet. Manufacturers that prioritize sustainable sourcing of MAPs and environmentally friendly production methods can gain a competitive edge in the market. Incorporating bioactive compounds from MAPs is a key focus, offering diverse health benefits. Manufacturers can create beverages that contribute to overall health by leveraging MAPs bioactive components. Success depends on the effectiveness of these beverages

in promoting health and meeting consumer demand. Consumers increasingly seek FBs with tangible health benefits like immunity enhancement and cognitive function improvement. The viability of FBs relies on scientific validation and providing tangible benefits to consumers. In essence, the future of FBs is characterized by innovation, sustainability, and a steadfast commitment to meeting consumer demand for products that not only taste good but also contribute positively to their health and the well-being of the planet.

13. Conclusion

In conclusion, MAPs serve as a natural and abundant resource for enhancing existing functional products or creating novel ones. Incorporating MAPs into FBs not only enhances their nutritional value but also introduces a wealth of health benefits to consumers. MAPs are rich sources of bioactive compounds such as polyphenols, flavonoids, and essential oils, known for their antioxidant, antimicrobial, and anti-inflammatory properties. Furthermore, the unique flavors and aromas imparted by MAPs add depth and complexity to FB formulations, elevating the sensory experience for consumers. However, before fully leveraging the potential of MAPs in FBs, several challenges such as stability issues and determining the appropriate dosage need to be overcome. Nanoencapsulation of EOs emerges as a promising solution to improve stability and prolong shelf-life while maintaining the effectiveness of bioactive compounds. Furthermore, the approval process for new flavorings in beverage production requires rigorous toxicological and metabolic evaluations to ensure compliance with safety regulations. It is essential to adopt a systematic and forward-thinking approach to incorporating MAPs into FBs, aiming to develop beverages that not only satisfy taste preferences but also promote overall health and well-being. By addressing these hurdles with innovation and diligence, the FBs industry can continue to evolve and offer consumers a diverse range of healthful and flavorful options for hydration and wellness.

Conflict of interest

The authors declare no conflicts of interest relevant to this article.

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