

Fortified Beverages

Pragya Tiwari¹, Preethi Ramachandran², Nabila Arshad¹ and Alina Rehman¹

¹M. Tech Scholar, Department of Post-Harvest and Process Engineering, G.B Pant University of Agriculture and Technology, Pantnagar, Uttarakhand Pin code - 263145.
Teaching Personal, Department of food Technology, G.B Pant University of Agriculture Technology, Pantnagar, Uttarakhand

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Abstract

Fortified beverages have emerged as a significant trend in the beverage industry, offering enhanced nutritional profiles to address specific dietary needs and promote overall health and wellness. This comprehensive review explores the historical background, development, and market trends of fortified beverages, highlighting the importance of fortification strategies in addressing nutrient deficiencies and improving public health outcomes. Key nutrients commonly fortified in beverages, including vitamins, minerals, electrolytes, probiotics, omega-3 fatty acids, and plant extracts, are discussed, along with the stability, bio accessibility, and bioavailability considerations essential for maximizing their nutritional impact. Various fortification strategies, such as direct addition, encapsulation, biofortification, and targeted fortification, are examined for their efficacy in delivering essential nutrients to consumers. Examples of fortified beverages across different categories, including fruit juices, dairy products, plant-based alternatives, sports drinks, and functional beverages, are presented to illustrate the diverse range of fortified products available in the market. Furthermore, regulatory frameworks governing the fortification of beverages, challenges and limitations associated with over-fortification, sustainability concerns, and future trends in the fortified beverage industry are discussed. Overall, this review provides valuable insights into the role of fortified beverages in addressing global nutrition challenges and shaping the future of the beverage market.

Keywords

Fortified beverages, Nutrients, Historical background, Vitamins, Minerals, Electrolytes, Probiotics,, Prebiotics, Omega-3 fatty acids, Plant extracts, Phytonutrients, Fortification strategies, Direct addition, Encapsulation, Biofortification, Targeted fortification,



Stability, Bio accessibility, Bioavailability, Fortified Fruit Juices Fortified Dairy Products Fortified Plant-Based Milk Alternatives Fortified Sports and Energy Drinks Fortified Functional and Nutritional Beverages Market trends, Consumer perception, Regulation

Introduction

Fortified beverages represent a significant evolution in the beverage industry. A fortified beverage is a type of beverage that has been enhanced with additional nutrients, typically vitamins, minerals, or other bioactive compounds, beyond what is naturally present in the base ingredients to address specific nutritional needs and promote overall health and wellness. The process of fortification involves intentionally increasing the nutrient content of the beverage to address specific dietary deficiencies or to provide additional health benefits. Fortified fruit juices, for example, provide a convenient source of vitamins like vitamin C and vitamin D, while fortified dairy products offer essential nutrients such as calcium and vitamin B12 to support bone health and immune function. Sports drinks fortified with electrolytes help replenish fluids and maintain hydration during physical activity, while functional beverages incorporate ingredients like probiotics, antioxidants, and plant extracts to target specific health concerns. Common nutrients added to fortified beverages include vitamin D, calcium, iron, folic acid, and various B vitamins. Fortified beverages come in various forms, ranging from fruit juices and dairy products to sports drinks and functional beverages, each tailored to target different nutritional requirements and consumer preferences.

Historical background and development

The historical background and development of fortified beverages trace back to the early 20th century. One of the earliest instances of fortification dates to the 1920s when iodine was added to salt to combat iodine deficiency disorders like goitre. This success prompted further exploration into fortifying other food and beverage products. In the mid-20th century, the fortification of staple foods such as flour with vitamins and minerals became widespread, aiming to address malnutrition. The fortification of beverages such as milk and fruit juices were done with nutrients like vitamin D, calcium, and vitamin C. Over the decades along with providing various nutritional needs, fortified beverages offer convenience and accessibility, making it easier for consumers to incorporate essential nutrients into their daily routines.

Nutrients commonly fortified in beverages include:

Vitamins

- **Vitamin D:** Fortified in milk, fruit juices, and plant-based milk alternatives to promote bone health and support immune function.
- **B Vitamins (such as B6, B12, and folic acid):** Added to various beverages to support energy metabolism, neurological function, and red blood cell formation.
- **Vitamin C:** Often fortified in fruit juices and flavored water to boost the immune system and enhance antioxidant properties.

Minerals

- **Calcium:** Fortified in dairy and plant-based milk alternatives to support bone health and muscle function.
- **Iron:** Added to certain beverages to help prevent iron deficiency anemia, especially in populations at risk such as pregnant women and young children.
- **Zinc:** Sometimes included in sports drinks and functional beverages to support immune function and wound healing.

Electrolytes

- **Sodium, potassium, and magnesium:** Found in sports drinks and electrolyte-enhanced water to replenish electrolyte levels lost through sweat during physical activity and help maintain hydration and muscle function.

Probiotics and Prebiotics

- **Probiotic bacteria strains (e.g., lactobacillus, bifidobacterium):** Added to certain fermented beverages like kefir and kombucha to promote gut health and digestion.
- **Prebiotic fibers (e.g., inulin, oligosaccharides):** Fortified in beverages to serve as food for beneficial gut bacteria and support digestive health.

Omega-3 Fatty Acids

- Often found in fortified juices, milk, and plant-based beverages to provide essential fatty acids that support heart health, brain function, and inflammation regulation.

Plant Extracts and Phytonutrients

- **Polyphenols (e.g., flavonoids, anthocyanins):** Added to some fruit juices and herbal teas for their antioxidant properties and potential health benefits.
- **Green tea extract, ginseng, and other botanical extracts:** Included in certain functional beverages for their purported health-promoting properties, such as enhanced energy and cognitive function.

Fortification Strategies for fortification in Beverages

Direct addition is a prevalent strategy in fortifying beverages, entailing the straightforward incorporation of essential nutrients directly into the beverage during production. This method ensures precise control over nutrient levels, allowing manufacturers to tailor the beverage's nutritional profile to meet specific dietary needs and health goals. For instance, enriching milk with vitamin D or fortifying fruit juices with calcium enhances their nutritional value and bolsters bone health. By fortifying beverages through direct addition, manufacturers can effectively address nutrient deficiencies and provide consumers with convenient and accessible sources of vital vitamins and minerals. Moreover, this approach enables the creation of fortified beverages that offer targeted health benefits, such as supporting bone density and reducing the risk of osteoporosis. As a result, direct addition stands as a cornerstone strategy in the fortification of beverages, facilitating the production of nutritionally enhanced products that contribute to improved public health and well-being.

Encapsulation serves as a sophisticated mechanism for fortifying beverages, involving the encapsulation of essential nutrients within protective shells or carriers. This process safeguards the nutrients from degradation due to environmental factors such as light, heat, and oxidation, ensuring their stability and efficacy within the beverage. Encapsulation can be achieved through various techniques, including spray drying, fluidized bed coating, and liposome encapsulation. Fluidized bed coating involves coating the nutrient-containing particles with a protective layer, such as a polymer or lipid, using fluidized bed technology. Liposome encapsulation entails entrapping the nutrients within phospholipid bilayers to form lipid vesicles, which act as protective carriers. Once encapsulated, these nutrient-loaded particles or vesicles can be easily dispersed in the beverage matrix without altering its taste, texture, or appearance. Upon consumption, the encapsulated nutrients are released gradually, ensuring sustained delivery and enhanced bioavailability. Encapsulation offers several advantages in beverage fortification, including improved stability, controlled release, and enhanced solubility of the fortified nutrients. Additionally, encapsulated nutrients can be tailored to meet specific formulation requirements and address targeted health concerns. Overall, encapsulation represents a versatile and effective strategy for fortifying beverages with essential nutrients, contributing to the development of functional and nutritionally enhanced products that support consumer health and well-being.



Biofortification is a transformative mechanism employed in fortifying beverages, involving the enhancement of nutrient content in raw ingredients prior to beverage production. This process aims to enrich crops with essential vitamins, minerals, and other nutrients during their growth and development stages. Through conventional breeding techniques or biotechnological approaches, such as genetic engineering or marker-assisted selection, crops are selected or modified to accumulate higher levels of specific nutrients. For instance, biofortified crops may be engineered to produce elevated levels of vitamin A precursors, iron, zinc, or other micronutrients. Once harvested, these nutrient-enriched crops serve as the primary ingredients for producing fortified beverages. By integrating biofortified ingredients into beverage formulations, manufacturers can create products with enhanced nutritional value and health-promoting properties. Biofortification offers a sustainable and cost-effective approach to addressing nutrient deficiencies, particularly in regions where access to diverse and nutritious foods is limited. Moreover, biofortified beverages provide consumers with a natural and bioavailable source of essential nutrients, supporting overall health and well-being. As research and development in biofortification continue to advance, the potential for incorporating biofortified ingredients into fortified beverages holds promise for improving public health outcomes and addressing global nutrition challenges.

Targeted fortification is a strategic approach utilized in the fortification of beverages, focusing on addressing specific health concerns or dietary deficiencies within targeted consumer demographics. This mechanism involves the deliberate addition of nutrients to beverages to meet the unique nutritional needs of a particular population group or to address prevalent health issues. For instance, beverages fortified with iron and folic acid may target pregnant women to prevent anaemia and support fetal development. Similarly, fortified beverages enriched with calcium and vitamin D may cater to older adults to promote bone health and prevent osteoporosis. Targeted fortification strategies are based on scientific evidence and epidemiological data, identifying key nutrient gaps or health concerns within specific demographic groups. By tailoring fortification to meet the nutritional requirements and health goals of target populations, manufacturers can develop fortified beverages that offer targeted health benefits. This approach not only enhances the nutritional value of beverages but also ensures that fortified products effectively address the health needs of consumers, contributing to improved public health outcomes and consumer well-being. As consumer

awareness of targeted fortification grows, the demand for fortified beverages customized to meet specific health concerns and dietary preferences is expected to increase, driving further innovation and development in the fortified beverage industry.

Examples of fortified beverages

Fortified Fruit Juices:

- **Tropicana Orange Juice with Added Calcium and Vitamin D:** This fortified orange juice provides an additional source of calcium and vitamin D, supporting bone health and overall nutritional intake.
- **Ocean Spray Cranberry Juice Cocktail with Added Vitamin C:** This fortified cranberry juice cocktail offers extra vitamin C, contributing to immune system support and antioxidant benefits.

Fortified Dairy Products:

- **Yoplait Original Yogurt with Vitamin D:** Yoplait Original yogurt is fortified with vitamin D, helping to support calcium absorption and bone health.
- **Silk Almond Milk with Added Calcium and Vitamin E:** Silk almond milk is fortified with calcium and vitamin E, offering a dairy-free alternative with additional nutrients.

Fortified Plant-Based Milk Alternatives:

- **Oatly Oat Milk with Added Vitamin D:** Oatly oat milk is fortified with vitamin D, providing a plant-based source of this essential nutrient for bone health.
- **So Delicious Coconut Milk Beverage with Added Vitamin B12:** So Delicious coconut milk beverage is fortified with vitamin B12, offering a dairy-free option with extra nutritional benefits.

Fortified Sports and Energy Drinks:

- **Gatorade Thirst Quencher with Added Electrolytes:** Gatorade Thirst Quencher is fortified with electrolytes like sodium and potassium, helping to replenish fluids and maintain hydration during physical activity.
- **Red Bull Energy Drink with Added B Vitamins:** Red Bull Energy Drink contains added B vitamins such as niacin, vitamin B6, and vitamin B12, providing an energy boost along with essential nutrients.

Fortified Functional and Nutritional Beverages:

- **Bai Antioxidant Infusion with Added Antioxidants:** Bai Antioxidant Infusion beverages are fortified with antioxidants like vitamin C and vitamin E, offering hydration with extra health benefits.
- **Orgain Organic Protein Almond Milk with Added Protein:** Orgain Organic Protein Almond Milk is fortified with plant-based protein, providing a nutritious beverage option for individuals seeking additional protein in their diet.

Stability, Bio accessibility, and Bioavailability of Fortified Beverages

Stability, bio accessibility, and bioavailability are critical factors in ensuring the efficacy and nutritional impact of fortified beverages. Stability refers to the ability of fortified nutrients to retain their chemical and physical properties over time, during processing, storage, and distribution. Maintaining stability is essential to prevent degradation or loss of potency, which could compromise the nutritional value of the beverage. Factors such as pH, temperature, oxygen exposure, and light can influence the stability of fortified nutrients.

Bio accessibility refers to the release of fortified nutrients from the beverage matrix during digestion, allowing them to become available for absorption in the gastrointestinal tract. Achieving optimal bioaccessibility is crucial to ensure that fortified nutrients are effectively released and absorbed by the body. Factors such as particle size, surface area, and interactions with other components in the digestive system can influence the bio accessibility of fortified nutrients. Beverage formulations may be optimized to enhance bioaccessibility through techniques such as particle size reduction, emulsification, and encapsulation, which improve nutrient dispersion and solubility in the gastrointestinal environment.

Bioavailability refers to the proportion of fortified nutrients that are absorbed and utilized by the body after ingestion. It depends on factors such as nutrient form, chemical structure, and interactions with other dietary components. Some fortified nutrients may exhibit low bioavailability due to poor solubility, limited absorption, or interactions with dietary inhibitors. Beverage formulations can be optimized to enhance bioavailability through strategies such as selecting bioavailable nutrient forms, improving nutrient dispersion, and incorporating enhancers or synergists that facilitate nutrient absorption.

Overall, ensuring the stability, bioaccessibility, and bioavailability of fortified nutrients in beverages requires careful formulation and processing techniques. By optimizing these factors, beverage manufacturers can develop products that deliver maximum nutritional impact

and health benefits to consumers. Additionally, continued research and innovation in areas such as encapsulation technologies, nutrient delivery systems, and gastrointestinal physiology will further advance our understanding of how to optimize the nutritional efficacy of fortified beverages, ultimately promoting public health and well-being.

Market Trends and Consumer Perception of fortified beverages

Market trends and consumer perception of fortified beverages are heavily influenced by shifting dietary preferences, health consciousness, and emerging nutritional research. Manufacturers are responding by introducing a diverse array of fortified beverages targeting specific health concerns, such as bone health, immune support, and energy enhancement. Moreover, there is a growing emphasis on natural and organic ingredients, transparency in labelling, and sustainability practices, reflecting consumer preferences for healthier and environmentally conscious products. Despite these positive trends, challenges remain, including consumer scepticism regarding the efficacy and necessity of fortification, as well as concerns about added sugars and artificial additives.

Regulation

The regulatory framework surrounding fortified beverages is multifaceted, encompassing international regulations and standards aimed at ensuring product safety, efficacy, and accurate labelling. Internationally, organizations such as the Codex Alimentarius Commission establish guidelines and standards for food fortification, including fortified beverages. These standards serve as a reference for national governments in developing their own regulations.

National regulatory bodies, such as the Food and Drug Administration (FDA) in the United States and the European Food Safety Authority (EFSA) in the European Union, oversee the approval and labelling of fortified beverages within their respective jurisdictions. These agencies assess the safety and efficacy of fortified ingredients and set maximum levels for fortification to prevent overconsumption and potential health risks. In many countries, fortified beverages must also display nutrition facts panels detailing the product's nutritional content per serving size. Additionally, regulations govern the use of health claims and nutrient content claims on product packaging. Claims such as "good source of calcium" or "excellent source of vitamin C" must meet specific criteria and be supported by scientific evidence.



Compliance with regulatory standards and labelling requirements is essential for fortified beverage manufacturers to ensure consumer safety, build trust, and facilitate international trade. By adhering to these regulations, companies can demonstrate their commitment to producing high-quality fortified beverages that contribute to public health and meet consumers' nutritional needs.

Challenges and Limitations

Fortified beverages offer promising solutions to address nutrient deficiencies and enhance public health, but they also present several challenges and limitations that must be carefully considered. One significant issue is the risk of over-fortification, where excessive levels of added nutrients may lead to adverse health effects. Overconsumption of certain vitamins and minerals, such as vitamin A, iron, and calcium, can potentially cause toxicity or interfere with nutrient absorption, particularly when fortified beverages are consumed in conjunction with other fortified foods or supplements. Striking the right balance between fortification levels and safety is crucial to mitigate these risks. Furthermore, sustainability concerns loom over the production and distribution of fortified beverages. The sourcing and processing of fortifying nutrients, such as vitamins and minerals, may have environmental impact. Addressing these sustainability challenges requires adopting eco-friendly practices throughout the supply chain, from ingredient sourcing to packaging and distribution.

Moreover, maintaining stability and bioavailability of fortified nutrients poses technical challenges. Some nutrients may degrade or lose efficacy during processing, storage, or exposure to light and heat, compromising their nutritional value. Ensuring the stability and bioavailability of fortified nutrients requires careful formulation, packaging, and storage conditions, as well as ongoing research to optimize delivery systems and enhance nutrient absorption rates. By addressing issues related to over-fortification, sustainability, and nutrient stability, fortified beverage manufacturers can maximize the potential health benefits of their products while minimizing risks and environmental impacts, ultimately contributing to improved public health and well-being.

Future of fortified beverage industry

The future of the fortified beverage industry holds promise for continued growth and innovation as consumer awareness of nutrition and wellness continues to rise. Market trends suggest a shift towards personalized nutrition solutions, driven by advancements in technology



and data analytics. Consumers are increasingly seeking fortified beverages tailored to their specific health needs, preferences, and lifestyles. This trend is expected to drive the development of customized formulations, targeted fortification strategies, and personalized product offerings. Moreover, as sustainability concerns gain prominence, the industry is likely to witness a greater emphasis on eco-friendly packaging, responsibly sourced ingredients, and transparent supply chains. Additionally, advancements in food science and technology will enable the creation of fortified beverages with improved stability, bioavailability, and functionality, further expanding the range of health benefits offered by these products. Overall, the future of the fortified beverage industry is characterized by innovation, customization, and sustainability, positioning it as a key player in the global health and wellness market.

Conclusion

The production and consumption of fortified beverages address crucial nutritional needs and contribute significantly to overall health and well-being. In today's fast-paced world, where dietary imbalances and nutrient deficiencies are prevalent, fortified beverages offer a convenient and accessible solution to supplement essential vitamins, minerals, and other bioactive compounds. These beverages play a vital role in filling nutritional gaps, particularly in populations at risk of deficiencies, such as pregnant women, children, and the elderly. By fortifying beverages with key nutrients like vitamins, minerals, electrolytes, probiotics, and omega-3 fatty acids, manufacturers can provide consumers with functional and nutritionally enhanced products that support various aspects of health, including bone health, immune function, energy metabolism, and digestive health. Additionally, fortified beverages offer flexibility and versatility, catering to diverse dietary preferences, lifestyles, and health goals. Whether it's fortified fruit juices, dairy products, plant-based milk alternatives, sports drinks, or functional beverages, there is a wide range of options available to meet the specific needs and preferences of consumers. Moreover, the fortification of beverages aligns with public health initiatives aimed at reducing the burden of nutrition-related diseases and promoting healthy lifestyles. As consumer awareness of the importance of nutrition and wellness continues to grow, the demand for fortified beverages is expected to increase, driving further innovation and development in the fortified beverage industry. Overall, fortified beverages serve as valuable tools in promoting optimal nutrition and supporting overall health, making them indispensable components of a balanced diet and lifestyle.

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