Recent Development and Future Direction in Production of Gluten-Free Rice Bread

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Summary

In recent years, health has been one of the issues that must be concerned in order to meet the needs and acceptance of consumers, in which gluten-free rice bread (GFRB) is also one of the top concerns. Rice is a staple food source and a major source of carbohydrates in daily diets around the world. This review synthesizes new and innovative research on GFRB in recent years and reviews the effects of ingredients and possible techniques to improve the GFRB properties quality. With an abundant annual production, rice and its products are always a top concern for researchers, nutritionists and economists. The application of modern technologies in the treatment and processing of GFRB has been studied deeply and extensively. With this review, it is possible to give a deeper insight into the implemented issues and new directions for this available and abundant source of rice, especially for the sustainability and development of the rice-based developing country.

Key words

bread quality, gluten-free rice bread, rice, rice-based products

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Introduction

Celiac disease (CD) is an intestinal disease caused by gluten-containing grains such as wheat, barley and buckwheat and their products, in people with susceptibility genes (Henggeler et al., 2017). For nearly a century, the medical profession has acknowledged CD, which is observed to affect 1% of Caucasians, and its prevalence is increasing in Asia and China (di Cagno, 2016). The only viable and successful strategy to relieve its symptoms is to provide patients with a gluten-free (GF) diet due to its numerous and complex causes. Recent research has studied two aspects that were reducing the content of wheat flour in processing by glutent-free materials and totally using the glutent-free material for production of foods (Giau et al., 2024; Kunyanee et al., 2024; Van Tai and Thuy, 2024). Among that, rice, corn, sorghum, millet and potato are the most common basic grain materials used to make gluten-free dishes. With the increasing population in the world, rice is considered the main source of food for daily meals (Ahmed et al., 2018). Rice is also one of the world's most important food crops, with yearly production estimated at around 510.8 million tons. Compared to other foods, rice is the most accepted raw material by consumers. Rice is a significant source of carbohydrates, which makes up more than 70% of the weight of the rice grain, depending on the type of grain (Loan et al., 2024). Rice starch is also considered a gluten-free material, which does not contain gliadin (Wu et al., 2019). Rice starch is also a good component of vitamins and minerals that help with resistance, and simple digestibility food. Rice flour differs from rice starch in that most of the flour's natural proteins and lipids have been removed. Starch contributes a major role in rice bread quality, and starch functions can be significantly improved by appropriate modification (Aoki et al., 2020; Aoki et al., 2012).

Replacing fresh flour with appropriately modified starch could potentially increase bread quality (Amagliani et al., 2017; Bender and Schönlechner, 2020; Boulemkahel et al., 2021b; Capriles et al., 2021; Chen et al., 2021; Loan and Thuy, 2019; Van Tai et al., 2023). Rice bread manufactured from rice flour could offer a new approach in rice processing, increase rice utilization, and address the need for gluten-free bread, which also, by offering antioxidants with its colored varieties leads to reducing the glycemic index of product (Ngo et al., 2022). Because of the quick and ongoing development and changes in the gluten-free bakery business (ingredients, technologies, and customer needs), an increasing number of GF bakeries are arriving on the market and supplying freshly baked, preservative-free bread products. The global market for GF products continues to expand rapidly, projected to grow from \$6.7 billion in 2022 to over \$14 billion by 2032 (Park and Kim, 2023), reflecting not just medical necessity but also a trend of health-conscious consumers adopting GF diets.

The global surge in demand for gluten-free (GF) foods (driven by celiac disease and health trends) has positioned rice as an ideal base for GF breads due to its wide availability, hypoallergenicity, mild taste and easy digestibility (Park and Kim, 2023). In many rice-producing regions, transforming rice into bread adds value and caters to changing consumer habits – for instance, in Asia the decline in per capita rice consumption has coincided with increased bread consumption, prompting the development of rice-based breads to utilize surplus rice and reduce reliance on imported wheat (Jeong et al., 2021). Unlike plain cooked rice, rice flour bread allows incorporation of technologies like fermentation or fortification to enhance nutrition and shelf life, creating novel functional products (Thomas et al., 2023). Rice, traditionally consumed as a staple, is increasingly being explored as a base for gluten-free bakery products. This shift is driven by multiple factors, including growing consumer demand for gluten-free alternatives, changing dietary habits and opportunities to add value to surplus rice. Technologically, rice flour offers hypo-allergenicity, mild flavor, and good digestibility, making it suitable for gluten-free bread development. Moreover, transforming rice into bread can address declining rice consumption trends in some regions, while providing innovative, functional foods with extended shelf life, improved nutrition and broader market reach (Jeong et al., 2021; Park and Kim, 2023; Thomas et al., 2023). This paper examines recent developments in gluten-free rice bread, as well as some key components and possible processing effects on quality during breadmaking, to gain a deeper understanding of the deep inside of bread improvement. Giving insights into the future direction of using locally and abundantly available ingredients to improve rice bread properties also reported.

Recent Research on Gluten-Free Rice Bread Production

Gluten-free products or gluten-free bread, nowadays, are in increasingly high demand in modern life and are considered an interesting topic by many researchers. In recent years, the development of gluten-free bread has been investigated with various starch sources such as corn, potato, rice and gluten-free wheat. Among these ingredients, rice flour is a promising source to produce GF products thanks to several advantageous properties such as gliadin-free, easily digestible, colorless commodity, tasteless (Wu et al., 2019). However, the native rice flour properties are not appropriate for bread processing due to the retrogradation properties as well as lack of protein content in network formation. The starch properties and starch structure were correlated with the quality of bread made from rice flour. The term GFRB is commonly used to refer to a GFB that is intended as a bread substitute and uses mainly rice flour (Boulemkahel et al., 2021b), but it generally has characteristics different from wheat bread. The GFB recipes contain mainly rice or maize flours combined with potato, maize or wheat starches that have been researched by many authors in recent years. Using pigmented rice flour in the GFB was applied mainly due to pigmented rice flour and was not only available and good eating quality source but also good source of phytochemical compound (Gusmão et al., 2019; Thiranusornkij et al., 2019). The specific volume of bread was positively correlated with the amylose content in rice flour (Aoki et al., 2020). The GFRB is the most difficult to produce, tends to retrograde, and becomes crumbly when it is stored at low temperature for a few days due to the interaction of amylose-amylopectin inside starch granules. The study of the cooperation of rice flour and sweet potato flour in GFB product was also studied (Franco et al., 2020). Amylose dominated in the bread aging process at the initial stage and the crystallization of amylopectin occurred at the last stage. The optimization processing condition of gluten-free "Cẩm" rice bread was developed (Loan and Thuy, 2019; Loan et al., 2018). Loan et al. (2021) also was examined the combined effect of two types of enzymes on the quality of GFRB. Due to the lack of gluten network, various studies about the improvement characteristics of structure of GFRB investigated different treatments, as applying protease treatment (Kawamura-Konishi et al., 2013), using transglutaminase (Renzetti et al., 2008), and addition of glutathione (Yano, 2010, 2012). The research of Hatta et al. (2015) showed the effectiveness impact of *Bacillolysin*, papain, and subtilisin on the quality of gluten-free rice bread. Bread was made with waxy and non-waxy rice flours of similar amylopectin structure at various mixing ratios, which also was investigated by Yano et al. (2020). The baking rate of bread increases when it depends on the amylose content of rice flour, which has partially been applied in various gluten-free foods such as bakery and pasta. Differences in odorants and their precursors were also investigated and compared between GFRB and wheat flour bread. The generation of fragrance components is heavily influenced by the bread-making process. Hexanal was discovered as a key indicator of aging in bread and rice flour (Rohleder et al., 2019). Since 2022, further studies have refined the optimal characteristics of rice flour and processing for GFRB. For instance, rice flour with low starch damage (~4–6%) and a moderately coarse particle size (~150 μm) was found to yield higher loaf volumes and better texture in rice bread (Park and Kim, 2023). High-amylose, short-grain rice cultivars consistently produce breads with greater specific volume and more uniform crumb cell structure than waxy (low-amylose) varieties (Park and Kim, 2023). Additionally, mild flour pre-treatments—such as partial pre-gelatinization of a rice flour slurry or the incorporation of sourdough fermentation—have been shown to improve gas retention and crumb softness in rice breads (Dan et al., 2022).

The Improvement of Gluten-Free Rice Bread by Non-Gluten Components

Recent research compares two strategies to improve gluten-free rice bread: (a) modifying rice flour's physical or biochemical properties and (b) replacing or supplementing rice flour with functional ingredients such as hydrocolloids and enzymes. Flour modification through pre-gelatinization, enzymatic hydrolysis, or particle-size control can enhance dough performance, specific volume and crumb texture without synthetic additives. For instance, proteolytic treatment of rice protein improves dough viscosity and softness (Park and Kim, 2023). While additives like xanthan gum or modified starches enhance structure, flour-centered approaches support clean-label trends and may reduce cost and allergenicity (González et al., 2024).

Rice Flour

Rice flour is the main ingredient in gluten-free rice bread, and it is also a promising cereal ingredient for product creation because of its natural, hypoallergenic and colorless properties, as well as its bland flavor (Ngo et al., 2023; Van Ngo et al., 2024). Because rice contains a small quantity of prolamin, appropriate additives such as gums, emulsifiers, and dairy products must be used to boost the system's consistency or viscosity. Modification of rice flour, on the other hand, is a practical solution (Luangsakul and Van Ngo, 2025; Van Ngo and Luangsakul, 2025). Previous studies have used physical modification of rice flour for GFRB making (Dhull et al., 2021; Fonseca et al., 2021), which improves the functional properties of rice flour and produces agent-free material. In addition, modification avoids the occurrence of starch retrogradation during the storage of starch-rich food products. Besides, physically modified flour is the preferred material with the least level of health risk (Bisinella et al., 2022). Immature rice grain, which is one of the by-products of paddy milling process, the effects of the infrared stabilized immature rice grain flour (IRGF), substitution on proximate composition, cooking properties, crumb and crust color, mineral composition, vitamin B_1, B_2, tocopherols, gamma-oryzanol, texture and sensory properties of the breads were evaluated by (Özer et al., 2018). The texture profile of bread as hardness, adhesiveness, gumminess, and chewiness pronouncedly increased with the replacement of IRGF at the level of 50% or higher. GFB incorporated with 30% IRGF was the most preferred bread, based on the score of consumers' overall acceptance. In addition, the rice used to make GFB is mainly polished rice (Roman et al., 2019). However, the GFB made with polished rice is prone to nutritional imbalance because polished rice is obtained by removing the entire bran layer, leaving mainly starch and protein. The low temperature mill was applied on brown rice flour, which was also used for gluten-free rice bread production (Luo et al., 2021). GFB prepared with medium-sized brown rice flour had large specific volume, low hardness, numerous and homogeneous gas cells, all considered as favorable characteristics. Particle size and type of rice grain contributed to the quality of bread including physicochemical properties and sensory value (Tóth et al., 2022). Using low pressure homogenization was also considered as the promising technique for modification of starch in order to use it for bread making process (Boulemkahel et al., 2021a). Recent research has shown that amylose content in rice flour plays a critical role in the development of GFRB (Aoki et al., 2020; Yano et al., 2020). The physicochemical properties of rice bread were caused by the amylose content and amylopectin architecture, while bread expansion was attributed to the change of the double helices. Less concave in shape and higher specific loaf volume was found in rice bread made from high-amylose cultivars (Aoki et al., 2020). The texture and hardness of the bread were directly related to the amylose content of the used rice flour, which was a positive correlation. Therefore, it is necessary to consider the amylose content of rice starch in balancing the degradation process and the crumb structure of the bread. Furthermore, rice gluten-free bread made with high percentage of long branched amylopectin chains varieties provided a stiffer and harder structure than bread made with short chain amylopectin varieties (Aoki et al., 2012). Amylose reorganization prevailed in the early stages of retrogradation and aging of the bread, whereas in the latter stages, recrystallization of amylopectin occurred. Therefore, it could be seen that the ratio of amylose and amylopectin in rice flour plays an essential role, which directly affects the quality and storage capacity of gluten-free bread (Chen et al., 2021). Because carbohydrate-active enzymes react particularly with carbohydrate components in complex food systems, such as starch, enzyme technology has several potential applications in the baking business. Amylolytic enzymes are used to improve the softness, freshness, and shelf life of starch-based foods like baked goods (Park et al., 2018). On the alteration of bread starches, the combination of these two enzymes had a synergistic impact. The transfer reaction used D-enzyme to change the amylose/amylopectin ratio, whereas amylase shortened the amylopectin branch chain. The anti-staling properties of the enzymatically modified GF rice bread were outstanding throughout storage, suggesting that structural modifications in rice starch could prevent bread starch retrogradation (Bangar et al., 2022). The findings indicate that the amylose content and branch chain length distribution of amylopectin influence the physicochemical parameters of GF rice bread. As a result, simultaneous enzyme treatment is critical for starch modification, as each enzyme preferentially targets amylose and amylopectin molecules. Furthermore, plant-derived enzymes are safe and even helpful to human health, so they can be employed broadly. Future research should focus on temperature and time, dough formula and enzyme concentrations to further improve the combined enzyme treatment procedure. Emerging physical modification techniques such as ultrasound and microwave treatments have also proven effective at enhancing rice flour functionality for breadmaking. For instance, moderate ultrasonication of rice flour introduced microscopic cavitation bubbles and increased the batter's viscoelasticity, which in turn improved rice bread quality – the specific volume of bread increased by ~15.6% and crumb hardness decreased by ~17.6% after ultrasound treatment of the flour (Qin et al., 2022). By contrast, a conventional hydrothermal pre-treatment (moist heat) was found to overly gelatinize the starch, yielding a denser, harder loaf (Qin et al., 2022). These findings underscore that controlled ultrasound or other novel physical processing can significantly improve GFRB texture and appearance without the need for chemical additives.

Other Gluten-Free Components

The recent development of GFRC mushrooming has discovered various flour sources and ingredients. It could be seen that three main components included rice flour, alternative protein and enzyme directly affected and impacted on the improvement on the GFRB.

Hydrocolloids/Gums

Hydrocolloids are commonly employed to help improve the quality and shelf life of food goods by thickening and gelling them (Woomer and Adedeji, 2021). Hydrocolloids such as HPMC and XG are commonly employed in the manufacture of GFB (Monteiro et al., 2021). This is because HPMC can improve batter consistency, quality of bread texture (Morreale et al., 2018), and specific volume of GFB (Belorio and Gómez, 2020). XG could improve crumb structure and higher specific volume in the finished products (Repo-Carrasco-Valencia and Vidaurre-Ruiz, 2022). Hydroxypropyl methylcellulose, carboxymethylcellulose, locusta, guar, and xanthan gums, pectin, and -glucan are some examples of hydrocolloids used to improve gluten-free bread qualities. In general, hydrocolloids are added at quantities ranging from 1 to 4 percent (flour base), with 1 to 2 percent yielding the greatest volume and texture characteristics, however this might vary depending on the formulation and processing conditions (Franco et al., 2020; Repo-Carrasco-Valencia and Tomás, 2022). Beyond these traditional hydrocolloids, novel starch-free thickeners are being explored. One example is modified tamarind seed xyloglucan, a thermoresponsive gum that gels upon cooling. Adding 0.5–0.7% of this gum (a modified tamarind gum, MTG) to rice bread dough was found to produce a softer, moister crumb and to significantly slow down crumb firming during storage, with only a slight reduction in loaf volume (Fujii et al., 2023). Breads made with this MTG hydrocolloid were notably preferred in sensory tests due to their enhanced softness and prolonged freshness (Fujii et al., 2023). Such temperature-sensitive hydrocolloids represent a new approach to improving GF bread quality and shelf life while minimizing the use of conventional additives. Meanwhile, driven by clean-label trends, recent research has demonstrated the feasibility of baking high-quality rice breads without any added gums by optimizing processing parameters. A study developed gum-free gluten-free rice bread by pre-hydrating the rice flour and reducing mixing time; the resulting loaf achieved a specific volume comparable to a xanthan gum-containing control (2.97 mL/g vs 3.11 mL/g) (González et al., 2024), though the gum-free bread did exhibit faster staling (crumb firming) than its gum-containing counterpart. This finding suggests that careful control of hydration and mixing can compensate for the absence of hydrocolloids, producing acceptable bread structure, and that additional anti-staling strategies may be needed if gums are removed.

Alternative Protein

Rice has different characteristics from wheat, making it a safe cereal for anyone with wheat allergy or celiac disease (Amagliani et al., 2017). As a result, GFB contains rice as an ingredient. Despite the lack of gluten, no major adjustments to the breadmaking process have been recommended when rice flour is used instead of wheat, even though the dough's qualities have altered throughout the years. Gluten from wheat, rye, barley, and other closely related cereal grains triggers celiac disease in genetically vulnerable consumers. Celiac disease is currently treated by adhering to a GF diet for the rest of one's life. (Tomar et al., 2022). Gluten is an essential structure-building protein that is required for the formulation of high-quality baked goods; thus its substitution provides a substantial technological obstacle. The lack of protein functionality in non-wheat cereals is a major stumbling block in the development of GF foods. Furthermore, commercial GF mixtures typically only contain carbohydrates, limiting the quantity of protein in the diet significantly. Various ways of including protein-based ingredients and modifying functional characteristics for GF product creation have been attempted in the recent past (Krupa-Kozak et al., 2018; Santos et al., 2021). Rice bran protein was also used for bread making (Phongthai et al., 2016). Due to lack of protein content in rice starch which do not possess these viscoelastic properties and cannot generate a gluten-like network. Soybean has been included in gluten-free formulations to confer structure and gas-retaining properties in rice batter (Krupa-Kozak et al., 2018; Marco and Rosell, 2008; Sciarini et al., 2010). The suitability of low-pressure homogenized long rice flour and medium rice flour with faba bean flour as raw ingredient in GF breadmaking without additives was successful production (Boulemkahel et al., 2021b). Supplementation of canola proteins on rice flour bread could be also applied to form dough matrix during oven baking (Salah et al., 2019). Other ingredients as ovoalbumin, β-conglycin, soymilk showed the sufficient application in bread production (Espinosa-Ramírez et al., 2018; Mancebo et al., 2017; Nozawa et al., 2016). Thus, scientists have been searching for alternative proteins that offer a new and more natural approach, gaining relevance in recent years due to their functional and nutritional aspects, which are vital for GF rice breadmaking (Bender and Schönlechner, 2020; Capriles et al., 2021). New protein fortifiers have emerged from both plant and novel sources. In particular, pulses like pea and lentil are being used as protein isolates to boost the nutritional profile of rice-based breads, often alongside hydrocolloids or emulsifiers to improve the batter structure (González et al., 2024; Ziobro et al., 2016). These protein supplements can help mimic some of gluten's functionality by improving batter stability and gas retention (Yano et al., 2017). Moreover, edible insect proteins are under investigation as sustainable, high-quality alternatives. For example, researchers have incorporated defatted mealworm (Tenebrio molitor) protein isolate into gluten-free bread formulations and used enzyme (transglutaminase) plus ultrasound treatment to improve its integration (Gharibzahedi and Altintas, 2024). This innovative approach not only enhances the protein content of rice bread but also enables the delivery of additional nutrients like vitamin B_{12} (cobalamin) naturally present in insect protein (Gharibzahedi and Altintas, 2024). Such novel protein ingredients, when properly treated and optimized, could provide the essential amino acids and structure-forming capability needed to produce more nutritious and satisfying GFRB.

Enzyme

Because their proteins lack the visco-elastic characteristics seen in gluten, using GF grains in the manufacture of GF breads is technically challenging. The use of enzymes in gluten-free batters has recently been researched to increase protein networks and elastic-like behavior by protein cross-linking (Renzetti and Rosell, 2016). In a previous study, during breadmaking process, protease treatment was used for production (Kawamura-Konishi et al., 2013), using transglutaminase (Renzetti et al., 2008; Repo-Carrasco-Valencia and Tomás, 2022), addition of glutathione (Yano, 2010, 2012). Transglutaminase, a protein cross-linking enzyme, has been used to improve the rheological properties of rice batter, although it did not affect the volume of rice bread (Manhivi et al., 2020). Transglutaminase boosted the elastic-like behavior of batters made from buckwheat and brown rice flours, resulting in considerable improvements in the textural features of breads, according to these studies. The textural enhancements, however, were accompanied by a reduction in specific volume. Furthermore, the enzyme had no effect on the breadmaking ability of sorghum and teff flours, implying that in corn flour, a deamidation reaction rather than protein cross-linking was stimulated. Other enzymes, other as transglutaminase, may be advantageous in boosting the breadmaking performance of GF flours, because the influence of the enzymatic treatment on flour functionality is reliant on the specificity for the substrate and the functioning of the changed protein structures. In the baking science, oxidative enzymes like glucose oxidase are particularly useful as bread improvers. Glucose oxidase (EC 1.1.3.4) is a catalytic enzyme that catalyzes the oxidation of glucose to gluconic acid and hydrogen peroxide. In the gluten network, hydrogen peroxide promotes inter and intra molecular disulfide bonds (Dahiya et al., 2020). Treatments with glucose oxidase increase dough strength and stability, loaf volume, and crumb structure and tenderness in baking applications (Dahiya et al., 2020; Wang et al., 2018). As a result, glucose oxidase may be useful in the effort to stimulate the creation of a protein network, so boosting the breadmaking capability of gluten-free flours. D-enzyme and β-amylase from plant botanical also shown the effectiveness, when they applied in gluten-free rice breadmaking (Le Loan et al., 2021). Recently, enzymatic approaches targeting starch retrogradation have shown remarkable success in prolonging GFRB freshness. In particular, applying a dual-enzyme treatment combining a branching/cyclizing enzyme (D-enzyme) with an α-amylase can greatly retard staling. This simultaneous enzyme treatment modifies the rice starch: the D-enzyme alters amylose–amylopectin structure while α-amylase shortens amylopectin chains. The result is a gluten-free rice bread that stays softer for longer, as the modified starch resists retrogradation (Le Loan et al., 2021). In one study, this two-enzyme combination led to outstanding anti-staling performance over several days of storage, significantly improving bread shelf life without additional additives (Le Loan et al., 2021). This evidence of enzyme synergy suggests that targeted enzyme technologies could be a critical strategy for maintaining GFRB quality and extending its freshness in the future.

Innovative Technological Possibilities in Gluten-Free Rice Breadmaking Processing

Additives (alternatives) and substances (new) have received special attention in recent years to improve the quality of GF products. Research has mainly focused on modifying the recipe to improve the quality of gluten-free rice bread. However, the subsequent technological solutions received little attention, with only few studies addressing this issue. Several new and existing technologies can now be applied to gluten-free rice cakes including fermentation, high hydrostatic pressure, or non-thermal baking processes.

Sourdough (SD) is a traditional technique that has been used, but it is gaining interest again as a "novel" technique. Today, clean and green labels have shifted research on consumers' demand focus to find novel technologies that could produce high-quality GF bread with free additives. Reducing food additives lowers prices and eliminates the need to declare allergens (proteins, enzymes) in products. According to recent research, SD can be utilized to eliminate most of the issues connected with the manufacturing of low characteristics of GF breads while saving money, being healthful, and being environmentally beneficial if used in the appropriate quantities (Cappa et al., 2016). Volatile and antibacterial, lactic acid and exopolysaccharides produced during fermentation show positive effects on product quality (Bender et al., 2018). By affecting important structure-building components such as starch and arabinoxylans and increasing the solubility of proteins, the by-products of sourdough fermentation change the dough's properties, resulting in bread having a softer crumb texture. Some lactic acid bacteria strains produce exopolysaccharides such as extran, levan, glucan and fructan, which increase the texture and shelf life of bread while improving the rheological quality of the dough (Bender et al., 2018). Recent studies have shown promising results from applying sourdough technology in gluten-free rice bread. Incorporating 20–30% rice-based sourdough fermented with selected lactic acid baterias and yeast has been reported to improve bread specific volume, texture and overall sensory appeal. For example, Thomas et al. (2023) used Ofada rice sourdough and found enhanced softness, flavor, and mold resistance. Another study by Keramari et al. (2024) demonstrated that sourdough with chickpea-rice flour delayed staling and improved aroma and nutritional value. These findings suggest that rice sourdough fermentation can significantly elevate product quality and extend shelf life. Sourdough technologies, which can be used in the manufacturing of gluten-free bread, are one of the most promising bread technologies because they increase the sensory, nutritional and textural aspects of the bread at the same time.

HHP is a fairly modern/emerging processing method, applied mainly to fruit juice preservation without heat, and it could change the starch and protein functional properties, which significantly affects taking into account the rheology of the product (Ahmed et al., 2018; Lin and Fernández-Fraguas, 2020). Several studies have focused on the effect of HHP on the structural formation of GF bread. New and novelty heating technologies are an area increasingly popular with attention by the baking industry. Some of the attractive advantages include lower costs and times, but it still helps to retain or enhance the characteristics of the bread. Choosing the right baking technique could improve product properties such as crumb and crust formation, color and flavor development (Bender and Schönlechner, 2020). Therefore, the potential of combining technologies might be considered as a promising approach to develop high quality GF breads in the future. Another promising technique is the use of power ultrasound during dough preparation. Ultrasonic treatment (e.g., 35 kHz during mixing) can homogenize gluten-free batter and improve its gas-holding capacity by inducing cavitation and micro-mixing effects. In a recent study, applying ultrasound while mixing a GF dough led to a doubled dough volume and a 2–10% increase in final product yield (Ulasevich et al., 2020), indicating substantially better leavening. The ultrasonication also had a mild sterilization effect on the dough surface (Ulasevich et al., 2020), which could extend mold-free shelf life. This technology improved the rheological properties of the dough sufficiently to allow automatic shaping, suggesting it could be translated to breadmaking to produce lighter GFRB loaves without additional additives. As the research progresses, non-traditional processes like ultrasonics (and potentially other emerging methods such as pulsed electric fields or vacuum baking) – used in combination with sourdough fermentation and HHP – are expected to further narrow the quality gap between GF rice bread and conventional wheat bread.

Conclusion and Future Insights

Recent studies have focused on the formulation of commercial rice breads using not a single rice starch but using a combination of different flours and gluten substitutes (hydrocolloids, acidifiers, emulsifiers, leavening agents, preservatives, or flavorings) to improve the quality of cakes. Studies also show significant quality variation in different formulations. However, a few challenges still stand before the food industry and scientists, like the limited production of gluten-free products on the commercial market. Compared with the bread made from wheat flour, rice bread still needs to improve in texture as well as organoleptic properties. Therefore, finding an alternative source of gluten network in rice bread processing is especially difficult. Applying modern technologies to change the characteristics of rice flour is necessary to meet this process. Making use of available ingredients and gluten-free is also a practical solution. The innovative technologies applied to the bread processing process should also be studied and changed to suit the requirements of consumers. All local alternative protein sources (such as native beans or protein sources that are by-products of other production chains), provincial gluten-free flours and gluten-free ingredients are available for use. The COVID-19 pandemic has forced us to re-evaluate the importance of short supply chains and local manufacturing, and to be more concerned with health. The diverse combination of locally available raw materials can both create new products and meet the needs of sustainable development in the face of increasing consumer demand and the environmental impact of products. Gluten-free rice bread production will eventually follow health and sustainability trends. People are increasingly customizing GFRB to meet their dietary needs. Diabetics may prefer low-glycemic breads, whereas athletes may favor high-protein, fiber-rich ones. Researchers are investigating adding B-vitamins and iron to rice loaves to help gluten-free eaters get nourishment. Companies are replacing synthetic chemicals with natural fermentates, enzymes, and self-acting molecules to meet clean label demands. To improve supply chain sustainability and use regional crops and byproducts such as colored rice varietals, ancient grains and rice bran, gluten-free breads may use more locally produced components. Next-generation of gluten-free rice loaves can be healthier, personalized, and environmentally sustainable by combining innovative food technology with nutritional studies. These loaves will be safe, nutritious, and tasty in the future.

CRediT authorship contribution

Le Thi Kim Loan: drafted the manuscript and collected the information. **Nguyen Minh Thuy:** contributed to the editing of the manuscript and mainly supervised this work. **Ngo Van Tai:** Conceptualized, drafted the manuscript, and collected the information.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that may have influenced the work in this article.

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