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Slice breads, unconventional flours, and healthiness?

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Abstract

Bread is a staple food consumed daily in various cultures, whether in homemade or industrial forms. Over the years, the formulations of bread, initially made with refined flours, have evolved to meet consumer demands, which have recently shifted toward foods with reduced sugar and fat content, and higher fiber content. In line with this trend, the use of mixed flours in bread production has emerged as an alternative, aiming to combine consumers' desire for healthier products with the potential to develop and offer regional products to small communities with limited access to industrialized foods. Brazil has the opportunity to stand out in the market by promoting the use of mixed flours and fostering the utilization of sustainable regional products, thereby enhancing the availability of products from family farming.

Keywords: bamboo; bakery; family farming; unconventional ingredient; regionalization; healthy; sustainability.

Practical Application: The use of unconventional flours in sliced bread allows for the development of more nutritious and diverse products, increasing fiber and protein content.

1 INTRODUCTION

Baking is an ancient art, despite its uncertain origins, and it is deeply rooted in the culture of various countries, holding significant nutritional, emotional, and economic importance. Although bread varies in composition from culture to culture, wheat flour remains its fundamental ingredient due to its unique properties, particularly the presence of proteins that form the gluten network (Cauvain & Young, 2007; Hoseney, 1994).

To illustrate the prominence of baking in Brazil, the bread market generated 12.71 million reals in revenue last year, translating into the commercialization of 723 thousand tons of industrialized bread (ABIMAPI, 2023). Despite wheat flour's suitability for bread production, the wheat used for Brazilian industrial baking is cultivated in colder climates, such as Canada, the United States, and Argentina, and is imported to meet domestic demand.

In this context, regional development and the incorporation of regional raw materials into already well-established market products can help small communities diversify their access to food and nutrients. The use of mixed flours in bread production has been studied as a partial substitute for conventional wheat flour, although on a limited scale. Bibliometric database analysis is a tool that can assist in visualizing trends and assessing overall research on the subject.

This review compiles existing studies on mixed and unconventional flours, as well as wheat flour substitutes, with the aim of producing healthier and/or more sustainable breads. Our goal is to bridge established knowledge from the baking industry and academia with research conducted on the subject, presenting unconventional flours as an alternative for producing healthier breads that align with consumer trends.

2 METHODOLOGY

A general bibliographic search was conducted across five databases: Web of Science, ScienceDirect, Scopus, Scielo, and Google Scholar. For the development of Figure 1, the Elsevier Scopus data compiler was used with the following search sequence: ("bread AND making") AND ("baking") AND (flours). There were no restrictions regarding the language of publication. The articles were screened by reading the titles and abstracts, and all irrelevant papers were excluded.

A total of 302 documents were found, and all nonscientific articles were excluded. All original articles that investigated and reported information on breads produced with mixed flours between 2013 and 2023 were included, resulting in a final total of 257 documents. The information from the articles identified in the search was selected and exported in CSV format. Words that appeared in at least six documents were selected. A total of 92 terms were found after this analysis, and these terms were subsequently used to construct bibliometric term occurrence maps using the VOSviewer v1.6.19 software (Leiden University, Netherlands).

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3 RESULTS AND DISCUSSION

3.1 Breadmaking history

Cereals have been at the core of human nutrition for centuries. However, the way each continent and culture has explored wheat and its derivatives has been unique, resulting in breads with distinct characteristics. Climate and soil limitations for wheat cultivation have also influenced the specific features of breadmaking in different regions. Thus, the breads enjoyed in Asia may differ from those produced in the United States, and so on. There are breads with high, medium, and low specific volumes, which cater to diverse cultural preferences (Cauvain & Young, 2007).

The basic ingredients of breadmaking are wheat flour, water, yeast, and heat. This baking tradition has involved, and still involves, generations and families. Given the wide variety of bread types, it is necessary to understand the complex interaction between raw materials, baking methods, production environments, and bread consumption patterns, as well as consumer expectations, to fully grasp the importance of this food (Cauvain & Young, 2007).

Baking initially began at home, then in groups, and finally on an industrial scale. Wheat was milled using stone mills, grinding the grain entirely (bran, endosperm, and germ), resulting in dark-colored flour. With the invention of the roller mill, introduced during the Industrial Revolution, it became possible to mill the grain, separating the bran from other parts and producing a lighter-colored flour. Refined wheat flour was preferred for baking, largely because of its color: Ideally, white bread should be white (Cauvain & Young, 2007).

Industrial baking began in the United Kingdom and the United States and has since spread globally. In the early days of industrial breadmaking, the focus was on producing bread with excellent technological characteristics and extended softness, which led to the widespread use of fat in bread dough. Contrary to consumer demands at that time, current requirements are shifting toward cleaner labels, with fewer ingredients in various products (Cauvain & Young, 2007).

The industrialization of bread offers several advantages, from increased production volumes and broader product availability in markets that previously had limited access, to longer shelf life and greater convenience. Packaged bread can be stored at home and consumed at any time with a pleasant texture, eliminating the need to travel to purchase fresh bread (Cauvain & Young, 2007). A testament to this convenience is that, in 2018, the global bread market generated 69.745 million dollars in revenue, with Brazil ranking eleventh in the industrialized bread market, producing 462,000 tons annually (ABIMAPI, 2023).

The average daily intake of fiber and other essential nutrients for human health remains well below recommended levels. According to the World Health Organization (WHO, 2003), public interest in healthy eating has increased due to the high incidence of various human health disorders. In this context, the use of unconventional flours and regional ingredients has been successfully incorporated into bread production, and the benefits of whole-grain breads are being emphasized. Both of these topics highlight the dynamic nature of baking and will be explored further in this review.

3.2 Industrial breads

According to Brazilian legislation, bread is defined as "products obtained from wheat flour and/or other flours, added with liquid, resulting from the process of fermentation or not, and baking, which may contain other ingredients." These products can also feature various toppings, fillings, shapes, and textures, as long as the fundamental characteristics of bread are not altered (Brasil, 2005).

The technological quality of breads has been, and remains, a subject of extensive research. Desirable characteristics of bread include good volume, with the bread rising above the height of the mold, a firm, golden crust with a natural, uniform appearance, not too different from the color of the crumb; the crumb should have numerous, symmetrical alveoli without flaws, a fine and soft texture, uniformity, and a light color. The flavor and aroma should also be characteristic (Cauvain & Young, 2007).

Parameters such as the appearance of the bread, specific volume, crust and crumb color, crumb appearance, and texture are quality indicators for breads, proposed by El-Dash (1978) and still used in various baking studies today.

The breads available in the market are generally classified as either traditional or whole grain. Additionally, there are breads with added grains, oats, and other ingredients. These ingredient additions aim to improve the nutritional aspects of breads. To understand the nutritional characteristics of these products, Table 1 presents the proximate composition of breads sold in the Brazilian market in 2019.

As shown in Table 1, breads contain high levels of carbohydrates and lipids. In addition to the carbohydrates present in wheat flour, the addition of sugar to the dough increases this percentage. The lipid content is justified by its role in improving dough machinability and achieving the softness desired by consumers. In an effort to enhance the functionality of breads, the incorporation of fibers or the production of breads from whole wheat flour has been used as an alternative (Cauvain & Young, 2007).

By definition, dietary fibers are the "edible parts of plants or analogous carbohydrates that are resistant to digestion and absorption in the human small intestine with complete or partial fermentation in the large intestine" (DeVries et al., 2001). Numerous studies have presented the health benefits of fiber intake, aiding in the control of cholesterol, glucose, and blood insulin levels, as well as in the prevention of heart disease and type 2 diabetes. Thus, adding dietary fibers to the daily diet can provide all these benefits (Jenkins et al., 2002; Liu, 2002; Marlett et al., 2002).

The daily fiber intake recommended by the Brazilian Ministry of Health, through the Dietary Guidelines for the Brazilian Population, is 25 g of fiber per day (Brasil, 2014). As bread is widely consumed in Brazil at meals such as breakfast and snacks, incorporating fiber into its formulations could help meet the target set by the Ministry of Health.

Table 1. Nutritional information on the labels of industrialized sandwich breads available in the Brazilian market in the year 2019.

Bread	Claims	Ingredients	Nutritional composition in 50 g (2 slices)					
			Energetic value (kcal)	Carbohydrates (g)	Proteins (g)	Fats (g)	Fibers (g)	Sodium (mg)
Traditional[1]	Cholesterol-free and trans fat-free	Wheat flour enriched with iron and folic acid, sugar, soybean oil, gluten, salt, low-sodium salt, emulsifier stearoyl-2-lactyl sodium lactate, flour improver ascorbic acid, calcium propionate, and potassium sorbate	126	25	4.5	0.9	1.2	182
Traditional[2]	-	Wheat flour fortified with iron and folic acid, sugar, vegetable fat, salt, monocalcium and tricalcium phosphates, vitamins PP, B6, B1, and B12, emulsifiers stearoyl-2-lactyl lactate sodium, polysorbate 80, and fatty acid monoglycerides, calcium propionate	125	24	4.6	1.3	1.0	150
Whole grain[3]	Source of fiber, cholesterol-free, and trans fat-free	Whole wheat flour, wheat flour enriched with iron and folic acid, gluten, wheat fiber, sugar, soybean oil, salt, low-sodium salt, preservatives calcium propionate, and potassium sorbate	122	20	6.3	1.7	3.5	180
Whole grain[4]	Source of fiber, trans fat-free, and low in sodium	Whole wheat flour, 13-grain flour (oats, brown flaxseed, golden flaxseed, rice, sunflower, sesame, soybeans, rye, wheat, sorghum, triticale, barley, and Italian millet), corn flour, buckwheat, brown sugar, gluten, canola oil, refined sugar, light salt, emulsifier mono- and diglycerides of fatty acids, and preservative calcium propionate	116	20	6.7	0.8	3.2	63
Whole grain and Zero[5]	Source of fiber, cholesterol-free, and trans fat-free	Whole wheat flour, wheat flour enriched with iron and folic acid, gluten, wheat fiber, low-sodium salt, emulsifiers mono- and diglycerides of fatty acids, and esters of mono- and diglycerides of fatty acids with diacetyl tartaric acid, preservatives calcium propionate and potassium sorbate	109	21	5.4	0.8	2.8	188

[1,3 e 4]Same brand, different lines; [2,5]Same brand, different lines.

Whole-grain or fiber-enriched breads available in the market are typically formulated with the incorporation of wheat bran into the dough, which gives the product a slightly darker color than traditional bread, leading to consumer rejection. West et al. (2013) conducted a sensory study on whole-grain pasta and concluded that products made from whole wheat had a darker color, were rougher and firmer than refined products, and were also more prone to developing undesirable odors and flavors. These characteristics were perceived by consumers as grassy and cereal-like odors, resulting in reduced interest in the product.

However, this rejection can be mitigated by clarifying the health benefits associated with fiber-rich products. Sajdakowska et al. (2019) conducted a study on consumer behavior regarding whole-grain bread and their consumption intentions related to health benefits. When consumers were asked which type of bread they preferred, traditional or whole grain, most stated that they preferred white bread due to the pronounced taste of whole-grain products. However, when they were informed about the health benefits of consuming whole-grain products before tasting, the scenario reversed. Taking health benefits into account, most consumers, despite citing the strong taste of whole-grain products as a barrier, chose to consume whole-grain bread over white bread.

Many breads available in the market carry nutritional claims related to their benefits, as shown in Table 1. Health claims are added to labels to alert consumers to beneficial components and to promote the product, functioning as a positive marketing tool. For this reason, health claims must follow regulations to ensure they do not mislead consumers.

The Normative Instruction (IN) No. 75 (Brasil, 2022b) and the Resolution of the Collegiate Board (RDC) No. 429 (Brasil, 2022a), both issued in 2020, introduced significant changes to the nutritional labeling of foods in Brazil. IN 75 defines reference portion sizes for each type of food, which is essential for ensuring that nutritional labeling is consistent and comparable across similar products. For bread, the reference portion size of 50 g (two slices) must be followed, as established, allowing consumers to clearly understand the amount of nutrients per portion consumed.

RDC No. 429, in turn, establishes general requirements for the nutritional labeling of packaged foods, focusing on providing clear and accessible information to consumers, so they can make more informed food choices. This resolution primarily aims to increase transparency and make nutritional information easier to understand, which is particularly relevant in the context of breadmaking, where ingredient quality, such as the use of whole versus refined flours, is a growing concern.

One of the key advances brought by RDC 429 is the introduction of front-of-pack labeling, which must highlight the presence of high levels of added sugars (≥ 15 g per 100 g for solid foods), saturated fats (≥ 6 g per 100 g for solid foods), and sodium (≥ 6 mg per 100 g for solid foods) when present in quantities exceeding the established limits.

RDC 429 also imposes stricter rules for the use of nutritional and health claims on labels. For example, in order for bread to be marketed as "whole grain," it must meet specific compositional criteria established by law, such as containing at least 30% whole-grain ingredients, or having more whole grain than refined ingredients. This ensures that the term "whole grain" is used correctly and does not mislead consumers. There are also specific nutritional claims related to fiber content: For a product to claim "high in fiber" or "rich in fiber," it must contain at least 5 g of dietary fiber per serving (Brasil, 2022a).

These regulations are driving significant changes in the bread market in Brazil, as seen in Table 2. Manufacturers are being required to reformulate their products to meet the new requirements, which include increasing the amount of whole-grain ingredients and adjusting the levels of critical nutrients such as sugars, saturated fats, and sodium. Additionally, labels are being redesigned to comply with the new front-of-pack labeling standards, which can significantly influence consumer choices.

3.3 Unconventional flours in breadmaking

In tropical countries like Brazil, wheat production is insufficient to meet domestic demand, leading to the importation of wheat for bakery products. The production and search for foods

Table 2. Nutritional information on the labels of industrialized breads available in the Brazilian market in the year 2024.

			Nutritional composition 50 g (2 slices)						
Bread	**Claims**	**Ingredients**	**Energetic value (kcal)**	**Carbohydrates (g)**	**Sugars (g)**	**Proteins (g)**	**Fats (g)**	**Fibers (g)**	**Sodium (mg)**
Traditional[A]	Natural fermentation	Wheat flour enriched with iron and folic acid, sugar, soybean vegetable oil, vinegar, salt, gluten, preservatives calcium propionate and sorbic acid, emulsifiers mono- and diglycerides of fatty acids and calcium stearoyl-2-lactylate, acidulant citric acid, thickener cellulose gum, and flour improver ascorbic acid	127	24	Totals: 2.6 Added: 1.9	4.9	Total: 1.2 Saturated: 0.3 Trans: 0 Monoinsaturated: 0.2 Poly-unsaturate: 0.4 Cholesterol (mg): 0	1.5	189
Premium[B]	-	Wheat flour enriched with iron and folic acid, sugar, vegetable fat, salt, gluten, preservatives: calcium propionate and potassium sorbate, emulsifiers: soy lecithin and calcium stearoyl-2-lactylate, and antioxidant: ascorbic acid	127	25	Totals: 7.1 Added: 4.8	4.2	Total: 1.3 Saturated: 0.5 Trans: 0 Monoinsaturated: 0.4 Poly-unsaturate: 0.3 Cholesterol (mg): 0	1.6	188
Whole grain 30%[C]	Source of fiber, trans fat-free	Whole wheat flour, wheat flour enriched with iron and folic acid, brown sugar, vegetable fat, salt, wheat bran, oat flour, soy fiber, light salt, preservatives: calcium propionate and potassium sorbate, emulsifiers: mono- and diglycerides of fatty acids, and antioxidant: ascorbic acid	119	20	Totals: 2.3 Added: 1.2	5.5	Total: 1.8 Saturated: 0.7 Trans: 0 Monoinsaturated: 0.7 Poly-unsaturated: 0.4 Cholesterol (mg): 0	3.2	169
Whole grain 38% Premium[D]	Source of fiber, trans fat-free, and cholesterol-free	Whole wheat flour, wheat flour enriched with iron and folic acid, wheat fiber, gluten, sugar, soybean oil, salt, and preservatives calcium propionate and sorbic acid	118	20	Totals: 1.8 Added: 1.1	6.0	Total: 1.5 Saturated: 0.3 Trans: 0 Monoinsaturated: 0.4 Poly-unsaturated: 0.8 Cholesterol (mg): 0	3.0	178

B, C Same brand, different lines.

that support small-scale producers, especially those without unrestricted access to imported wheat, drive the use of mixed blends of wheat with other cereals, roots, legumes, and tubers (Shittu et al., 2007).

The use of composite flours can provide access to high-quality breads with increasingly regional characteristics. The advantages of using these flours include the encouragement of domestic and small-scale agriculture, strengthening family farming, and helping developing countries address issues such as nutrient deficiencies. In addition to enhancing the nutritional value of the breads to which they are added, mixed flours promote the regional and local consumption of ingredients, potentially strengthening local markets and sustainable economies (Fernández-Ferrín et al., 2018).

The demand for natural products, with reduced sugar and fat content, has also reached the baking market. In Brazil, the demand for whole-grain, multigrain, or health-beneficial products has grown in the past years (ABIP, 2018). Recent studies have shown that health-related labeling claims are the most attention grabbing for consumers and enhance the consumption of specific products as these consumers reported feeling better when consuming healthier products (Bornkessel et al., 2014).

Following this trend, data from Euromonitor (2019) presented in a report indicated that consumers are increasingly connected to their beliefs and ideals. This characteristic leads them to reject habits that are not recognized as healthy. Additionally, consumers are showing a stronger relationship with their communities and environments, seeking to consume products that can benefit their communities, living the experience of conscious consumption. A more recent report on food consumption trends by Euromonitor (2019) showed that consumers are increasingly favoring "free-from" foods in pursuit of a healthier and more natural diet, including biofortified alternatives and products as healthy as possible.

The co-occurrence map (Figure 1) provides an overview of the main research areas and connections between different topics in the field of breadmaking, baking, and flours. Over the past 10 years (2014–2024), 257 scientific articles were found, divided into three main clusters. The central purple cluster includes terms such as "bread," "dough," and "fermentation," indicating that these terms are interrelated in the literature on baking and bread production. The green cluster is focused on more technical aspects, such as "wheat," "flour," "chemistry," and "genetics," suggesting a focus on research into the composition and characteristics of ingredients. The orange cluster, which includes terms like "rheology" and "textures," is more related to the sensory and industrial aspects of bread production. The terms "bread," "wheat," "flour," and "baking" are located at the center and show many connections, indicating that these are widely discussed concepts in the research analyzed.

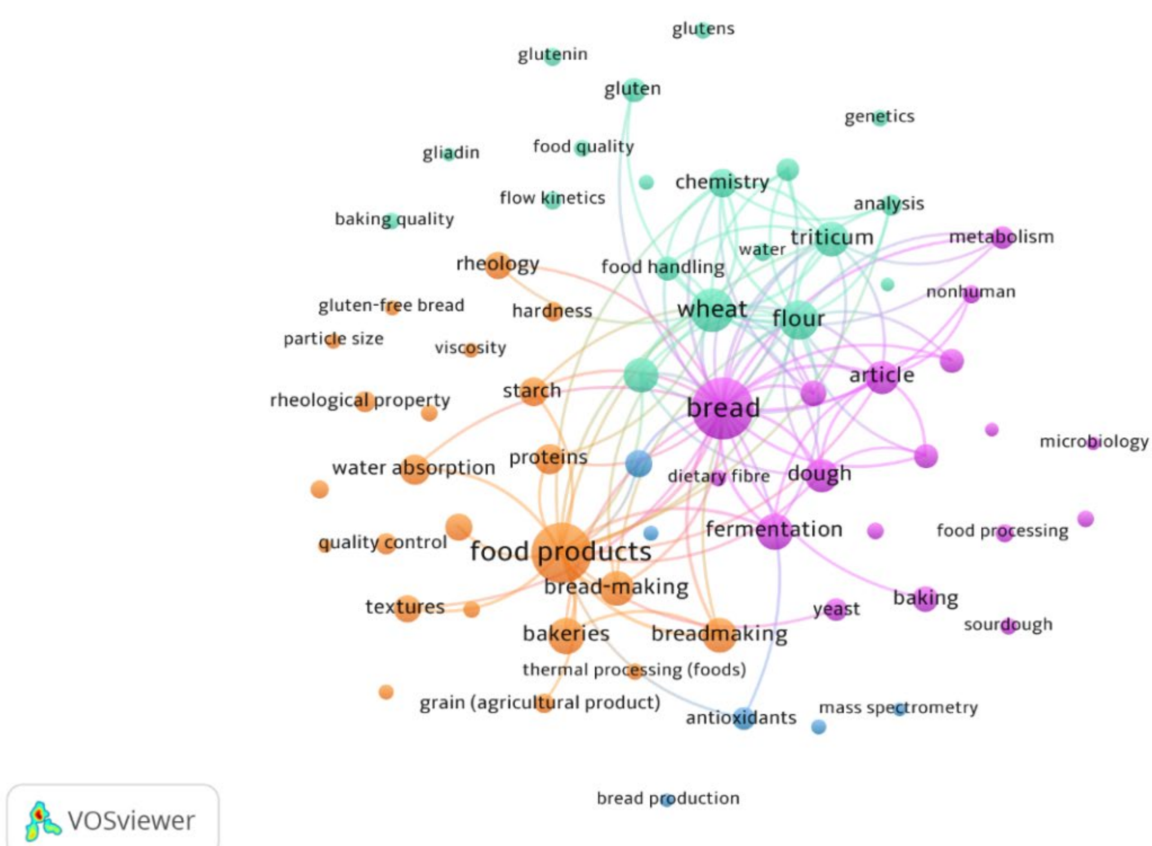

Figure 1. Network visualization map of publications on bread and flours in keyword co-occurrence clustering. Representation obtained using the VOSviewer software version 1.6.19.

In the bread market, reducing fat and sugar in formulations, using enzymes instead of additives, and incorporating natural, unconventional flours and ingredients have become popular alternatives. The use of tuber flours as a source of income for small-scale producers and their incorporation into bakery products, adding value to the final product, has been the focus of research in recent years, as discussed in the following paragraphs.

Breads made from non-wheat flours have been studied by various authors. Torbica et al. (2019) compared the use of thermally and hydrothermally pre-treated rice, oats, sorghum, and millet flours in bread production, investigating the technological effects of these treatments. All breads exhibited higher fiber content than wheat bread, and the best formulations were those with 70% thermally treated flour and 30% extruded flour, regardless of the cereal species used.

Yellow sweet potato flour was produced and incorporated into sweet bread by Nogueira et al. (2018) to enhance bread quality and increase its beta-carotene content. Wheat flour was substituted with yellow sweet potato flour at levels of 3, 6, and 9%. The yellow coloration of the tuber was prominent in the baked bread and persisted throughout the storage period, highlighting its potential use as a natural coloring agent. The beta-carotene content ranged from 0.1656 to 0.4715 μg/g, and these substitution levels were feasible in all percentages without altering the bread's technological characteristics, specific volume, or firmness up to nine days after production.

Pereira et al. (2019) evaluated the use of orange sweet potato flour in the preparation of sourdough and sponges for panettone. The authors observed that, with the inclusion of orange sweet potato, there was a slight reduction in panettone fermentation time, and the products exhibited increased moisture content and a yellowish crumb color, along with the presence of volatile compounds related to the new ingredient.

In pursuit of breads with enhanced protein profiles, Shrivastava and Chakraborty (2018) studied the partial substitution of wheat flour with fermented chickpea flour and xanthan gum in bread production. The fermentation of chickpea flour was optimized at 83 hours with 1.4% baker's yeast, a period during which the lowest phytate content and the highest concentration of free amino acids were obtained. Wheat flour substitutions ranged from 5 to 30% chickpea flour and 0.5 to 3% xanthan gum. The researchers identified the optimal formulation as 80% wheat flour, 18% chickpea flour, and 2% xanthan gum, which yielded characteristics closest to commercial wheat breads.

Other studies on the use of mixed flours in bread production are presented in Table 3.

Bamboo, known as the "plant of a thousand uses," is a significant grass that our research group has been studying. Data from the International Network for Bamboo and Rattan (INBAR, 2016) indicate a market valued at 60 billion dollars. China and Thailand lead the most well-established bamboo economies, while in Brazil, there is still a lack of formal data on production and market demand, despite Law No. 12,484, which established the National Policy for the Sustainable Management and Cultivation of Bamboo (Brasil, 2011).

Brazil possesses the largest native bamboo forest in the world, located in the Amazon, covering approximately 18 million hectares (INBAR, 2016). The country has 89% of the bamboo genera known globally and 65% of the species in the Americas. Paradoxically, while Brazilian forests are being deforested, bamboo cultivation has been progressively increasing (Pereira & Beraldo, 2007).

Bamboo shoots have long been consumed in Asian countries and were introduced to Brazil by descendants of this culture. Bamboo shoots are known to be rich in nutraceuticals and dietary fiber. In addition to the consumption of fresh and preserved bamboo shoots by the Asian and Oriental communities, studies on the application of bamboo shoot fiber (BSF) in food products have already been conducted due to its high content of dietary fiber and nutraceutical compounds. For example, Mustafa et al. (2016) added BSF to cookies, resulting in better sensory acceptance of fiber-enriched cookies.

Today, with consumers becoming increasingly demanding about the characteristics of the food they consume, the food industry seeks ingredients that are not only nutrient sources but also possess nutraceutical properties. Bamboo products have thus emerged due to their nutritional properties, mild flavor, and light color.

Felisberto et al. (2017a) developed flour from the young culms of Dendrocalamus asper bamboo, demonstrating the potential for bamboo's food use in Brazil. Subsequently, Felisberto et al. (2017b) compared the characteristics of three young culm flours obtained from the species Dendrocalamus asper, Bambusa vulgaris, and Bambusa tuldoides. The researchers once again obtained satisfactory results in terms of color, fiber content, and starches, making these flours suitable for use in formulations for cakes, cookies, and breads.

Ferreira et al. (2020) produced and evaluated whole cookies utilizing wholemeal flour and commercial BSF. The results indicated that the addition of BSF along with fat reduction, contributed to a decrease in mass spreading. Moreover, cookies containing fibers demonstrated a lighter color and greater hardness compared to the standard formulation. These findings suggest that BSFs have potential applications in cookie production, not only enhancing nutritional profiles but also aligning with consumer preferences for healthier products.

Highlighting the importance of incorporating high-fiber ingredients into main meals to enhance daily fiber intake, Ferreira et al. (2021) explored the formulation of fettuccine enriched with bamboo fibers (BFs) with two particle sizes (60 μm and 145 μm) in 3.5 and 7% substitutions of semolina in the formulation. Findings indicated that the fiber-enriched formulations exhibited a lighter color. Importantly, the results suggest that up to 7% BF can be incorporated into pasta without negatively impacting its color, texture, or flavor.

Regarding the sustainable chain of bamboo, the use of young bamboo culm flour is justified by the higher yield of flour produced from the culm compared to the shoot, as well as the possibility of sustainable management and extended maintenance of bamboo clumps (Felisberto et al., 2017b).

Table 3. Compilation of studies on the application of unconventional flours in the production of breads and their effects on the final product.

Ingredient	Wheat flour replacement (%)	Technological effects	Nutritional effects	Sensory effetcs	References
Yam starch (YS), cassava starch (CS), and whole wheat flour	10–60	Up to 20% substitution, there was no effect on the bread crust; above 20%, there was a loss of volume and severe defects in the crust	-	Breads with 20% CS and 30% YS showed greater sensory acceptance	Nindjina et al. (2011)
Cowpea	5–15	The greater the substitution, the lower the specific volume of the bread	Increases in the protein content of the breads compared to the control	The acceptability of the bread with 5% substitution did not differ from the control sample	Olapade and Oluwole (2013)
Mycelium flour from the mushrooms *Antrodia camphorata*, *Agaricus blazei*, *Hericium erinaceus*, and *Phellinus linteus*	5	The replacement did not affect the texture profile of the breads	The amino acid content of the substituted breads was higher	The substitution caused a decline in sensory acceptance for all the species studied	Ulziijargal et al. (2013)
Yam flour	25, 50, and 75	There was a loss of volume with increased substitution and the formation of cracks in the bread crust	An increase in protein content with increased substitution	Above 25% substitution, there was a decline in acceptability	Amandikwaa et al. (2015)
Lentil flour and carrot flour	5–24	A minimal level of substitution did not affect the bread volume; above 5%, there was a loss in volume, except for 10% carrot substitution, which increased the volume	Carrot and lentil flour contributed to increasing the lysine, protein, fiber, phenolic compound content, and antioxidant capacity of the breads	-	Turfani et al. (2017)
Bean flour (N) and fermented bean flour (F)	30	Breads made with bean flour showed no difference in specific volume compared to the control breads; both N and F improved the texture of the breads	The protein content increased from 11.6 to 16.5%; the glycemic index decreased from 100 (control) to 94% for N and 81% for F	-	Coda et al. (2017)
Apricot kernel flour	4, 8, 12, and 24	Beyond 8% of replacement: decline in quality in the dough and bread. Apricot flour breads exhibited a more yellowish color	-	Above 8% substitution, there was a negative influence on acceptability	Dhen et al. (2018)
Psyllium seeds and husks	4 and 8	Breads with 8% psyllium husks (PH) exhibited greater specific volume than breads made solely with wheat flour	There was an increase in antioxidant capacity and dietary fiber content with higher levels of substitution	Breads made with psyllium seeds demonstrated greater sensory acceptance	Pejcz et al. (2018)
Potato pulp	10, 20, 30, 40, and 50	Above 30% substitution: effect of discontinuity in the gluten network, reduction in specific volume, and increased firmness; both the crust and crumb became lighter in color in proportion to the addition of potato pulp	There was a reduction in the glycemic index of up to 15%	-	Cao et al. (2019)

Despite these benefits, obtaining young bamboo culm flour is still challenging due to the lack of machinery and a supply chain for bamboo products.

In this context, the study of development, characterization, and definition of parameters for products derived from bamboo shoots can be a stepping stone for building this supply chain and for the utilization of bamboo as a food resource. Bamboo shoot flour presents itself as a potential unconventional flour for the production of bakery products due to its high dietary fiber content, which could increase the daily fiber intake of communities with deficient consumption. Additionally, it holds potential for use as a fat and sugar substitute in breads, reducing the caloric intake associated with these products and contributing to the development of unique flavors and aromas in breads.

4 CONCLUSION

The use of unconventional flours in breadmaking presents a significant opportunity for diversification and innovation in the food sector, promoting the production of healthier and more sustainable breads. By integrating regional and less traditional ingredients, it is possible not only to improve the nutritional value of breads but also to encourage family farming and strengthen local economies.

The studies reviewed in this work demonstrate that partial substitution of wheat flour with mixed flours can maintain or even enhance the technological, nutritional, and sensory properties of bread, depending on the proportions and processing methods used. Additionally, consumer acceptance of these products can be increased through effective communication of the health benefits associated with the consumption of whole-grain and higher-fiber breads.

However, despite these advances, there is still a way to go before these practices are widely adopted by the baking industry. Continued investment in research and development is necessary to optimize formulations and ensure that breads made with unconventional flours can compete in terms of quality and price with traditional products. Furthermore, public policies that encourage the use of regional ingredients can help expand the market and raise consumer awareness of the importance of healthier and more sustainable eating habits.

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