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Wheat bran proteins: An update on extraction, properties, and application

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ABSTRACT

The problem of food waste permeates the entire supply chain, and protein waste is a particularly significant concern due to the essential biological functions of proteins and their versatile chemical and physical properties. Proteins recovered from food waste can be repurposed to develop innovative materials and technologies. Given cereals' crucial role in human diets, billions of tons are produced annually, generating by-products during processing. Among these, bran is notable for its high-quality protein content, with potential applications in the food and pharmaceutical industries. Wheat, the second most produced cereal globally, results in millions of tons of wheat bran each year, mainly utilized for animal feed, leaving its protein content largely untapped and wasted. Despite extensive research over the decades focused on extracting proteins from wheat bran, commercial availability remains elusive. This is primarily due to the complexities involved in the extraction process. However, recent technological advancements offer more sustainable methods for protein extraction, keeping the issue of wheat bran protein utilization pertinent. This mini review highlights the ongoing necessity for research aimed at harnessing wasted proteins from cereal by-products, particularly wheat bran, underscoring its significance as a by-product in the global food industry.

1. Introduction

Today's world's population exceeds 8 billion people (WORLDOMETER, 2025), all needing food. Satisfying such a demand requires a large effort comprising a complex global food supply chain, which was 9 trillion US dollars by 2024 (WEF, 2025). So, the food industry is one of the largest and most complex.

Food waste occurs throughout the food supply chain, and protein waste is among the most prominent aspects of this topic due to the biological importance of these macromolecules and their chemical and physical versatility. Thus, proteins recovered from food waste can be used to develop novel materials and innovative technologies (Peydayesh et al., 2023; Yüncü-Boyacı & Serdaroglu, 2024).

In such a context, because of the importance of cereals in human nutrition, billions of tons of them are produced to meet demand, with the consequent generation of by-products during processing. Among the latter, bran stands out due to its high-quality protein content, so much so that its potential use in the food and pharmaceutical industries has been pointed out (Hadidi, Garcia, et al., 2024; Mendoza-Wilson et al., 2024).

Wheat is the second most widely produced cereal in the world, and most of it is used for milling, so millions of tons of wheat bran are produced yearly. Nearly ninety percent of the wheat bran is used for animal consumption (Rossi et al., 2024), but its proteins are not used, so they are practically wasted. For decades, efforts and research have been devoted to extracting proteins from wheat bran and making rational use of them, but despite this, there is no supply of these proteins on the market. There may be multiple reasons for this, but the most important is the difficulty of extracting these proteins. Today, technological advances allow for more sustainable proposals for protein extraction, so the issue of wheat bran proteins remains relevant.

This mini review aims to provide updated information emphasizing the need for research to utilize wasted protein from cereal by-products, especially wheat bran, which is a significant by-product of the global food industry.

2. Wheat bran is a source of underutilized good-quality proteins

Fig. 1 depicts the three main anatomical parts of a wheat grain: endosperm, bran and germ, accounting for 78 %–86 %, 11 %–18 %, and 2.5 %–3.5 %, respectively (Chen et al., 2024a). These percentages can vary based on factors such as the wheat cultivar and growing conditions. Wheat bran is rich in fiber, protein, minerals, and antioxidants (Chen

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et al., 2024b). Endosperm is released as flour and is the primary product during milling, whereas bran and germ are considered by-products.

In 2023, global wheat production reached nearly 809 million tons (FAO, 2025), with around 80 % designated for milling. This data suggests an estimated annual production of wheat bran at approximately 97 million tons, contributing to a dynamic global market (TRIDGE, 2025).

Wheat bran is botanically referred to as the pericarp but commonly known in milling terminology as bran. Structurally, the wheat bran comprises seven cellular layers, most dead, except for the aleurone layer, the innermost one, whose vegetative cells envelop the endosperm and the germ (Fig. 1). The aleurone is botanically part of the endosperm, but remains attached to the bran after milling, which is why it is considered part of it. The primary role of wheat bran (or pericarp) is to provide physical protection to the mature grain. Additionally, it contains various chemical compounds that serve as a defense system against microorganisms, insects, and environmental factors (Balandrán-Quintana & Mendoza-Wilson, 2018).

In terms of chemical composition, wheat bran is notable for its protein, which is of good quality due to a higher content of essential amino acids than wheat flour (Hadidi, Garcia, et al., 2024). The average total wheat bran protein content is 15.9 g/100 g on a dry basis (Shewry et al., 2009), and it is not evenly distributed between its layers. The aleurone contains the highest amount of protein, followed by the middle layer, and then the outer layer. This variation in protein composition highlights the specific roles of each layer. Most bran proteins are in the aleurone cells (22.9 %). Proteins of the intermediate layer are more abundant in the hyaline, with 16.8 %, followed by the testa, with 5.7 %, whereas tube cells and cross cells together have 5.1 % (Chen et al., 2024b). Table 1 outlines the protein content in the three major sections of wheat bran, along with their primary functions.

Table 1
Protein content and functions in the different layers of the wheat bran.[a]

Layer	Protein content (g/100 g)	Main function of proteins
Outer	0.04	Mostly oxidative stress- and defense related.
Intermediate	0.36	Oxidative stress- and defense-related, but more diverse than those of the outer layer.
Inner (aleurone)	15.6	More than half are globulin-like storage proteins. The remaining participate in diverse metabolic functions.

[a] Jerkovic et al. (2010).

It is estimated that 90 % of wheat bran is used for animal feed (Rossi et al., 2024), primarily for pigs and poultry, amounting to around 87.3 million tons. The proteins in wheat bran are not bioaccessible because they are either trapped inside cell walls, which are indigestible by monogastric animals, or they are dispersed among the bran layers, forming complexes with other components. Furthermore, in some regions, wheat bran is used as a heating fuel (Skřivan et al., 2024). Consequently, considering that 87.3 million tons of wheat bran with an average protein content of 15.9 % are destined for animal consumption, a rough estimate can be made that nearly 14 million tons of high-quality proteins are wasted worldwide each year.

3. Overview of wheat bran proteins

The protein profile of the pericarp changes with each stage during wheat grain development. Specific functional categories of proteins predominate in each stage, i.e., metabolism, storage, stress/defense, and others such as those involved in secondary metabolism. In the last

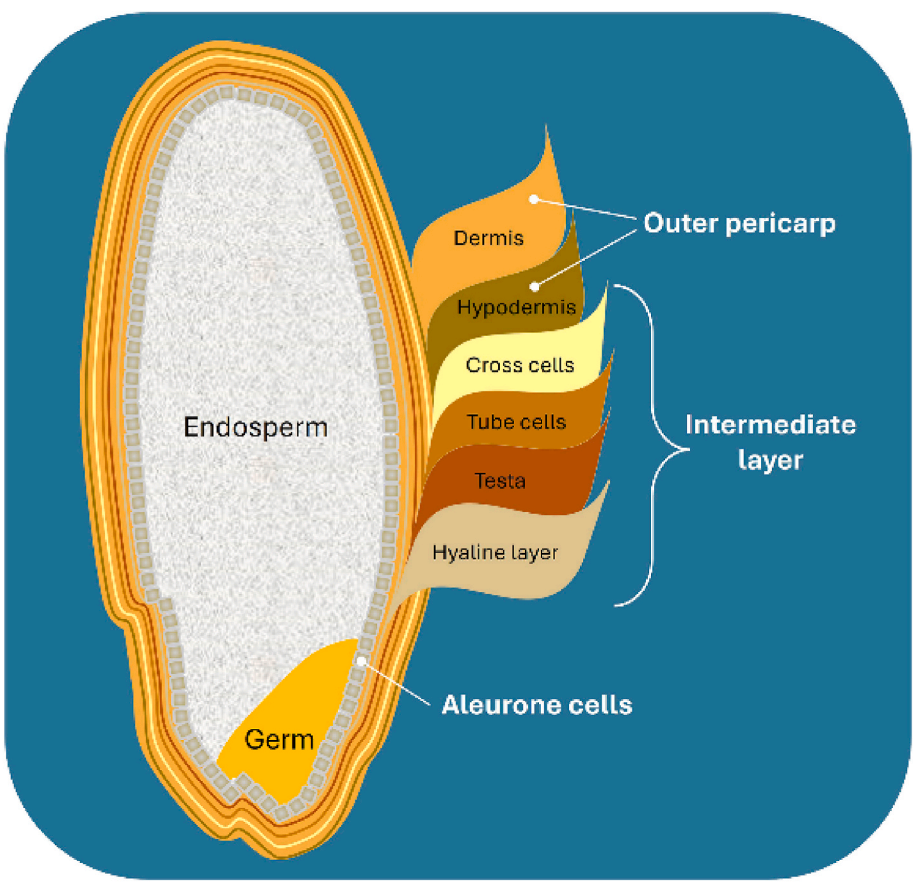

Fig. 1. A cross-sectional diagram, not to scale, shows a wheat grain's three main anatomical parts: endosperm, pericarp or bran, and germ. The bran consists of the outer pericarp, the intermediate layer, and the aleurone layer.

development stage, i.e., when the grain matures, the protein profile is dominated by storage, oxidative stress, and defense-related proteins (Balandrán-Quintana & Mendoza-Wilson, 2018). This section aims not to give detailed information about the biochemistry of wheat bran proteins but to highlight those properties that interest food technology and other related fields.

The protein and amino acid content of wheat bran varies according to several factors, so the results reported by different authors may be variable. However, these values generally fluctuate between cultivars and harvesting regions in relatively narrow intervals, so an average such as that in Table 2 (Shewry et al., 2009) is a reasonable estimate.

Wheat bran proteins contain the nine essential amino acids, as signaled in Tables 2 and in such amounts that, according to the USDA Standard Reference (NutritionValue, 2025), one portion of wheat bran (58 g) would apport the percentage of daily values shown in Table 3. Unfortunately, most the wheat bran proteins are not bioaccessible, as discussed in section 2, so neither are the essential amino acids. Nevertheless, an aqueous extract of wheat bran contains proteins, all of which have, on average, 42.7 % of essential amino acids (Chaquilla-Quilca et al., 2018), suggesting that aqueous extracts could be used as protein supplements or as ingredients to fortify foods.

In addition to the nutritional importance of wheat bran proteins, their functional properties are also noteworthy. Since the 1970s, the effect of incorporating these proteins into bakery products has been studied. Hansmeyer et al. (1976) prepared a protein-rich flour by washing the wheat bran with water and further spray drying the aqueous extract, as well as a protein concentrate from the alkaline extraction of wheat bran; then, white bread was fortified with one and other. In addition to a significantly higher protein and lysine content in the loaves of bread fortified with both extracts, the protein-rich extract did not significantly affect loaf volume when incorporated into flour at 5 %–10 % ratios. Furthermore, the sensory evaluation panel gave the same score to the fortified and the control bread regarding color, appearance, and texture of the crust, as well as aroma and flavor. On the other hand, fortification with the protein concentrate in proportions greater than 7 % negatively altered the characteristics of the loaf.

In a study by Idris et al. (2003), it was reported that the functional properties of total wheat bran proteins obtained by defatting and alkaline extraction of the bran, followed by acid and heat precipitation, depend on the medium's pH and NaCl concentration. The minimum and maximum solubilities were at pH 5.5 and 11.5, respectively, while the emulsification and foaming capacities and their stability were the lowest at acidic pH and high salt concentration. On the other hand, gels were only formed from a concentration of 16 % of protein dissolved in 1.0 mol/L NaCl. According to the authors, the water-holding capacity of 4.2 mL/g of protein was higher than that of commercial protein concentrates. In comparison, the oil-holding capacity of 1.7 mL/g of protein was considered good, although lower than that of soy flour.

Given this background, it is evident that wheat bran proteins have the potential to be incorporated into foods, but methods must be found that allow their extraction on a large scale.

Table 2
Amino acid composition of wheat bran.[a]

Non-essential aminoacids	(g/100g protein)	Essential aminoacids[b]	(g/100g protein)
Asp	7.2	Thr	3.3
Cys	2.0	Ile	3.5
Ser	4.5	Leu	6.0
Glu	18.6	Phe	3.9
Pro	5.9	His	2.6
Gly	7.1	Lys	4.0
Ala	4.9	Trp	1.6
Tyr	2.8	Val	5.0
Arg	7.0	Met	1.6

[a] (Shewry et al., 2009).
[b] (Lopez & Mohiuddin, 2025).

Table 3
Percentage of the daily values (DV) of essential amino acids provided by wheat bran, based on a bran portion of 58 g.[a]

Aminoacid	% DV	Aminoacid	% DV
Thr	18	Lys	11
Val	21	Trp	40
Ile	18	Phe + Tyr	22
Leu	16	Met + Cys	9
His	22		

[a] (NutritionValue, 2025).

4. Extracting wheat bran proteins

Plant-based proteins are presented as a viable alternative to the consumption of those of animal origin because they are a sustainable option (Hadidi, Hossienpour, et al., 2024). Although some plant proteins from specific sources do not have an adequate essential amino acid profile, they can be complemented with those from another source of plant origin; this is the case with corn and legumes (Gorissen et al., 2018). Proteins from other plant sources, such as wheat bran, have an excellent essential amino acid profile but are underutilized or wasted (Uttam et al., 2023).

Extracting plant proteins by conventional methods is laborious, not environmentally friendly, and can be deleterious to the protein quality. For that reason, the subject continues to be presented as a current area of opportunity, so emerging technologies such as ultrasound-assisted extraction, pulsed electric field, deep eutectic solvent, enzyme-assisted extraction, and combined methods are being investigated (Tang et al., 2024).

Onipe et al. (2021) published a comprehensive review detailing the benefits of processing wheat bran through milling, bioprocessing, and thermal treatments. They examined how these methods impact the functional, nutritional, and structural properties of wheat bran and explored its potential applications in food. The effects of bran processing on protein solubility and extractability vary depending on the method used, as highlighted in Onipe et al. (2021). This section will briefly revise as antecedents the conventional methods for extracting wheat bran proteins and provide an update on the strategies that have been investigated since 2021, which are summarized in Table 4.

4.1. Extraction by conventional methods

Sequential or Osborne extraction of wheat bran proteins was initially performed for their characterization (Breese Jones & Gersdorff, 1925). Given the importance of these proteins in biological quality and wasted quantity, in subsequent decades, attempts were made to extract them on a larger scale in search of some nutritional and functional applications (Uttam et al., 2023; Roberts et al., 1985). However, the disadvantages outweighed the advantages since, as far as we know, there are currently no wholesale suppliers of wheat bran protein concentrates or isolates on the market.

The biggest problem in extracting proteins from cereal bran is that most are found in the aleurone cells, surrounded by a cell wall (Li et al., 2023), so destructive methods must be used. Others are dispersed between the different layers of the bran (Jerkovic et al., 2010), often forming complexes with polysaccharides and other constituents, such as phytates.

Chemical methods have been used to extract proteins from wheat bran. The most common method is alkaline extraction followed by isoelectric precipitation, i.e., adjusting the pH to the isoelectric point of the proteins, generally between 4.0 and 6.0. This method was initially used to extract proteins from millruns, i.e., a mixture of bran, germ, and other wheat grain fractions separated from the endosperm (Saunders et al.,

Table 4
Summary of innovations in wheat bran protein extraction over the last 4 years.

Treatment	Featured considerations	References
Dual enzymatic treatment via alcalase and hemicellulase	• Protein content increment of 11.4 % in the extract. • Lower molecular weight (<21.1 kDa) and twice higher radical scavenging and digestive properties.	Zhuang, Li, Wang, Ke, et al. (2024)
Dual enzymatic treatment via α-amylase and protease	• Crude protein contents of up to 23 g/100 g in the freeze-dried extract.	Hanstein (2024)
Bioprocessing with lactic acid bacteria + fermentation	• Fermentation produced B12 vitamin up to 50–70 ng/mL. • It claimed that a protein-rich extract is obtained after bio-processing the wheat bran with lactic acid bacteria, but no protein concentration in the extract was reported.	Chamlagain (2024)
Superfine milling of wheat bran	•Albumin extractability increased 62 % compared to coarse bran. • Significantly higher *in vitro* protein digestibility (53.1 %) and hydrolysis degree (12.7 %) compared to coarse bran. • Intestinal digestion promoted the release of free amino acids in the superfine milled bran.	Li et al. (2023)
Ultrasound-assisted extraction	• Increased the solubility, emulsification property, and water retention capacity of wheat bran proteins after ultrasound treatment.	Xu et al. (2023)
	• Protein extraction yield increased from 2.43 to 3.07 % compared to control. • A higher lysine content than oats (5.43 vs 4.2 g/100 g protein) was found.	Uttam et al. (2023)
Pulsed electric field	• Increases protein extraction efficiency up to 23 % compared to alkaline extraction in rice bran. • Not reported for extracting wheat bran proteins.	Thongkong et al. (2023)

1976). The same method with some modifications was applied to extract proteins from wheat bran, and the functional properties of the proteins were tested in bread-making (Hansmeyer et al., 1976).

Alkaline extraction has its drawbacks. One is the salt accumulation during the process, which makes adding a dialysis step necessary, which adds more labor and water consumption. Contact with alkali could also affect the protein structure to the detriment of its biological quality and functional properties. Furthermore, since proteins are obtained as pellets, their solubilization requires pH far from the isoelectric point, thus avoiding their application in liquid or semi-solid food systems. The latter could be solved by extracting proteins in the aqueous phase, as suggested in the review of Janssen et al. (2024). Recent scientific literature about innovations in the extraction of wheat bran proteins indicates the topic remains relevant.

4.2. *Alternative methods for extracting wheat bran proteins*

4.2.1. *Bioprocessing*

Enzymatic and microbial bioprocessing to enhance the extraction of wheat bran proteins has been explored both in the recent past and decades ago (Arte et al., 2015, 2016, 2019; Roberts et al., 1985). However, the topic is far from exhausted, and bioprocessing variants are still being studied to improve protein extractability without compromising its quality. In this context, Zhuang, Li, Wang, Ke, et al. (2024) applied dual-enzymatic treatment via alcalase and *Bacillus velezensis* hydrolase and found an 11.4 % increase for proteins in the aqueous extract with enzymatic pretreatment compared to the extract without enzymes. The extract with enzymatic pretreatment had lower molecular weight (<21.1 kDa) proteins and twice higher radical scavenging and digestive properties.

In other study by Hanstein et al. (2024), the use of the Corolase® 7089 protease and the Termamyl® 120 thermostable α-amylase improved nitrogen compound extraction from wheat bran. Simultaneous and sequential treatments yielded similar results, with up to 23 g/100 g of crude protein concentration in the products.

The strategy of solubilizing wheat bran proteins by processing wheat bran with enzymes and microorganisms can be coupled with the fermentation of the protein-rich extract to increase nutritional quality. In work by Chamlagain et al. (2024) a two-step method was studied, the first of which was the bran processed with a starter culture containing lactic acid bacteria and yeast. The intention in the first step was to provide the necessary substrate so that, in the second step, the bioprocessed extract was fermented with a strain of *Propionibacterium freudenreichi* to produce vitamin B12. The extract obtained under optimal conditions had a vitamin B12 content of 5–7 μg/100 mL, which, according to the authors, is nutritionally relevant. A scale-up produced similar results, concluding that the process is robust and that the extract can be used to fortify foods.

4.2.2. *Physical methods*

To avoid the harmful effect of chemical reagents on the structure and properties of wheat bran proteins, attempts have been made to extract them using physical methods, which could be less aggressive, highlighting the following.

4.2.3. *Superfine milling*

It is reported that different types of milling of wheat, namely stone, roller, and pearl milling, result in various functional and antioxidant properties of bran, as well as regarding fiber, protein, lipid, and ash content (Saini et al., 2024). Other investigations indicate additional positive effects of direct bran milling.

Superfine milling is a method with several advantages to wheat bran processing. On the one hand, it reduces the grittiness sensation in the mouth, and it can be more efficiently metabolized by gut microbiota (Balandrán-Quintana & Mendoza-Wilson, 2022). Superfine milling disrupts aleurone cells, so most proteins are released, and their solubility and extractability are improved, as shown by Li et al. (2023). Besides significant increases of globulin, prolamin, and glutelin, albumin extractability of superfine milled wheat bran increased by 62 % compared with coarse wheat bran (Li et al., 2023). In superfine wheat bran with a particle size of 19 μm, 53.1 % *in vitro* protein digestibility and a hydrolysis degree of 12.7 % were found, both higher than measured in coarse wheat bran with 84–1110 μm particle size. Furthermore, intestinal digestion of superfine-milled wheat bran promoted the release of free amino acids, mainly arginine (16.4 %), tyrosine (12.8 %), and phenylalanine (9.5 %) (Li et al., 2023).

4.2.4. *Ultrasound-assisted extraction*

The cavitation effect of ultrasound causes a breakdown of the molecular structure of wheat bran proteins, resulting in an overall improvement of the functional properties. A recent study found significant increases in the solubility, emulsification property, and water retention capacity of wheat bran proteins subjected to ultrasonic treatment for 10 min. The effect was more pronounced at 15 min, but at a longer time, 30 min, the emulsion stability, foam stability, and oil absorption capacity decreased (Xu et al., 2023).

Uttam et al. (2023) used a combined method to extract wheat bran albumins, in which the albumins were first extracted, and then the residue was subjected to ultrasound treatment for 7 min. In this way, the protein extraction yield increased from 2.43 % to 3.07 %. Interestingly, the bran protein extracted with the combined treatment had a higher lysine content than oats (5.43 g/100 g protein vs. 4.2 g/100 g protein), the cereal with the highest lysine content.

4.2.5. Pulsed electric field treatments

Pulsed Electric Field technology is another plausible strategy for extracting plant proteins. It has been reported that, in wheat flour, treatment with electric pulses significantly removes proteins from the surface of starch granules, facilitating their extraction (Achayuthakan et al., 2023). Another study found that treating rice bran with electric pulses increases protein extraction efficiency up to 23 % compared to conventional alkaline extraction and improves protein functional properties (Thongkong et al., 2023). Besides removing proteins from starch granules, the electric pulses cause pore formation in cells (electroporation), facilitating proteins release. The enhancement of functional properties correlates with changes in the secondary structure of proteins, from random coils to α-helix and β-sheets (Thongkong et al., 2023). As far as we know, the pulsed electric field treatment has not been reported for extracting wheat bran proteins. However, the results from the studies above suggest that this technology could be effective for such a purpose, given the similarities of rice bran with wheat bran. Further research would be advisable to optimize pulsed electric field parameters and evaluate its applicability in protein extraction from wheat bran.

4.3. Considerations about protein extraction from wheat bran

Comparing the efficiency of protein extraction and the functional properties of different extraction methods is challenging due to the varying conditions reported in studies. Additionally, the presentation of results is inconsistent; some studies report yields, while others only provide protein content or omit this information altogether. The same inconsistency applies to the functional properties. As a result, previously published reviews on this topic, such as the one by Janssen et al. (2024), require extensive data to compile into a single table, yet meaningful comparisons remain elusive.

Moreover, no studies have simultaneously investigated multiple wheat bran protein extraction methods to directly compare their efficiencies and the impact of these methods on protein structure and functional properties. Therefore, further research is necessary to replicate optimized conditions for conventional extraction and to compare these results with those obtained using optimized conditions for novel extraction methods.

The available information shows that wheat bran protein extraction using novel methods such as bioprocessing, ultrasound-assisted extraction, superfine milling, or combined methods could be an environmentally friendly alternative, as pointed out equally for the extraction of other plant proteins (Chandran et al., 2024). Ultrasound-assisted extraction is one of the most advantageous methods to extract plant proteins, yet an exhaustive study has not been conducted on extracting those from wheat bran. Fig. 2 shows data comparing soybean protein extraction by several methods that support the potential benefits of ultrasound treatment (Das et al., 2023). Although yield and protein purity did not vary so much between methods, the performance of ultrasound-assisted extraction regarding the functional properties is noteworthy.

Additionally, the reported studies are on a laboratory scale, so studies that include scalability and cost analysis are required. The latter is needed to develop economically accessible technology that allows for large-scale extraction. A qualitative comparison of estimated costs, required equipment, and key considerations is shown in Table 5. The costs may vary depending on the supplier, equipment capacity, and technical specifications. However, it provides a gross estimation of the advantages and disadvantages of the extraction methods.

5. Applications for wheat bran proteins

Since wheat bran proteins are of good nutritional quality due to their amino acid profile, food fortification is one of the leading applications sought for them. Several studies have been conducted since the 1970s to fortify baked goods, and the topic remains interesting. In the study by Uttam et al. (2023), the incorporation of the wheat bran albumins into the wheat flour bread formulation increased loaf volume by 33.62 % and protein content by 1.62 %, relative to the control. In addition, the physical and sensory characteristics of the bread were better than those of the control.

In another study, the impact of adding wheat bran protein isolates (WBPI) and whey protein isolates (WPI) to baked goods to boost their nutritional value was examined. Fortifications of 5 %, 10 %, and 15 % with these ingredients were analyzed for their effects on dough properties. WBPI improved water binding but decreased dough quality, while WPI enhanced dough stability and development time. Notably, 5 % WBPI substitution improved energy and resistance, but higher levels reduced extensographic properties. Meanwhile, 5 % WPI substitution yielded better mechanical properties. However, baguettes with high WBPI led to lower acceptance due to a bitter taste from small peptides and other compounds (Pořízka et al., 2023).

Applications for wheat bran proteins have been recently investigated in food systems other than baked goods. There is interest in finding natural emulsifiers for producing food emulsions because conventional emulsifiers are being questioned regarding their impact on health and the environment (Kumar et al., 2022). Wheat bran protein isolates have

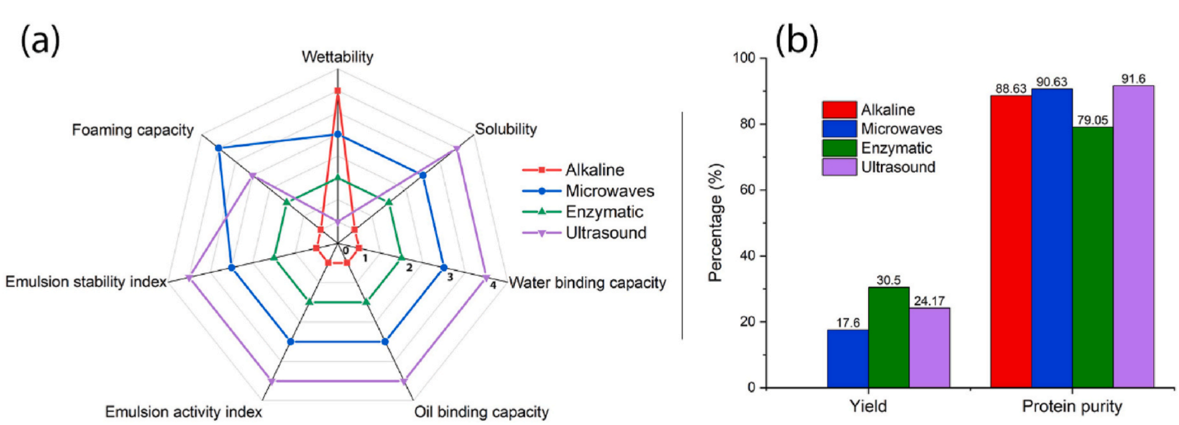

Fig. 2. Comparison of the functional properties (a) and yield and protein purity (b) of defatted soy flour proteins extracted by four methods, alkaline, enzymatic, microwave, and ultrasound. The higher the number, the better the treatment performance (a). With data from Das et al. (2023); yield of alkaline method was not reported.

Table 5
Qualitative comparison of some protein extraction methods in terms of costs, required equipment, and other considerations.

Method	Estimated Cost	Major required Equipment	Key Considerations	References
Alkaline Extraction	Low.	Agitators, centrifuges, pH meter.	• Affects protein functionality.	Sari et al. (2015)
Enzyme-Assisted Extraction	Moderate to high.	Lysis reactors, agitators, centrifuges, pH meter, tanks, pumps, spray- or freeze-dryer.	• Slower and more expensive process.	He et al. (2021)
Ultrasound-Assisted Extraction	Moderate.	Sonicators, centrifuges, pH meter.	• Significant increase in protein yield and functional properties. • Studies are mostly at laboratory-scale.	Rahman and Lamsal (2021)
Superfine milling	High investment and energy requirements.	Mill, air classifier, separators, feeder and cooling systems.	• Milling can produce wheat bran fractions with higher nutritional value.	Mavromichalis (2023) Rosa et al. (2013)

been proposed as natural emulsifiers for developing double emulsions to encapsulate labile bioactive compounds, such as anthocyanins. A study by Aktaş et al. (2024) found moderate stability of the emulsion with wheat bran proteins compared to that of other protein isolates such as soybean. However, it was recommended as a natural emulsifier if its performance is optimized. On the other hand, the encapsulation efficiency of the emulsions with bran proteins was very similar to that of the soy standard. In summary, wheat bran protein isolates are potential natural emulsifiers, but further research is required.

A study was conducted on the inclusion of wheat bran protein concentrate in spaghetti to enhance nutritional properties without compromising quality. Semolina was substituted with wheat bran proteins concentrate at 0 %, 1 %, 5 %, 10 %, and 20 %. The protein content in spaghetti increased from 12.3 % to 23.4 %, and total essential amino acids rose from 3.76 % to 7.59 % with wheat bran protein concentrate addition. Spaghetti quality remained acceptable up to 10 % concentrate, showing better appearance than wholemeal (Alzuwaid et al., 2021).

Other researchers have studied the possible use of wheat bran protein isolates for yogurt fortification. Adding 2 % or 5 % of the protein isolate to natural yogurt before fermentation increased the nutritional quality of yogurt due to the essential amino acid composition of wheat bran proteins, but rheological properties were also favored, such as greater viscosity due to a higher water retention capacity. Although the presence of protein isolates did not affect the fermentation process, the bitter taste of wheat bran did persist in the final product (Slavíková, Smatana, et al., 2024). In another similar study, Slavíková, Diviš, et al. (2024) found that sensory defects, such as bitterness and grittiness imparted by wheat bran protein isolate added to natural yogurt, could be masked by encapsulating the protein isolate with alginate.

Proposals for other potential applications related to food or pharmaceutics have emerged to utilize the proteins in wheat bran. Aqueous extracts of wheat bran are platforms for biomineralizing calcium phosphate dihydrate, or brushite, resulting in the synthesis of spherical particles (Zavala-Corrales et al., 2020). The proteins and zinc in the extracts could be responsible to some extent for the spherical morphology, a factor currently being investigated (Carreño-Márquez et al., 2023, 2025).

The use of wheat bran to develop meat analogues has not been specifically investigated, but its high protein and fiber content suggests it could be a potential source. This represents a research opportunity to evaluate its feasibility and efficacy in this context.

6. Bioactivity of wheat bran proteins

There are reports in the literature highlighting the potential applications of wheat bran extracts in the food and cosmetics industries. Their nutritional, antimicrobial, antioxidant, enzyme-inhibiting, and anti-aging benefits are particularly noteworthy, a topic recently reviewed by Kobayashi et al. (2025). Extracts are obtained by different methods, so the chemical composition of the extracts may vary depending on the method used. This section reviews the newest research on the potential health benefits of wheat bran peptides and proteins.

A novel antimicrobial peptide called WBp-1 has been isolated from wheat bran after ultrasound-assisted pepsin hydrolysis of wheat bran proteins. It demonstrated significant antibacterial efficacy against *Listeria monocytogenes* due to its ability to disrupt cell membrane integrity (Zou et al., 2025).

Another study reported that peptides prepared from wheat bran via protein hydrolysis with alcalase and *Bacillus velezensis* hydrolase exhibited significant antioxidant activities against H_2O_2-induced oxidative stress in the hepatic cell line HepG2 (Zhuang, Li, Wang, Li, et al., 2024).

The hypolipidemic effect of wheat bran consumption has been observed for decades, although it was unclear which of the constituents of wheat bran was responsible for this effect. A recent work studied the impact of feeding rats a high-fat diet with 5 % wheat bran protein on antioxidant activity, cholesterol metabolism, and lipids in serum and liver. A significant reduction was found in total cholesterol in both serum and liver, as well as triglyceride levels, low-density lipoproteins, and very low-density lipoproteins, while high-density lipoprotein levels, glutathione peroxidase, and total antioxidant capacity were significantly increased (Sun et al., 2023).

Therefore, accumulated evidence corroborates the potential of wheat bran peptides as novel antibacterial agents, food preservatives, nutraceuticals, and health-promoting bioactives.

7. Conclusion

Wheat bran proteins have high nutritional value and potential functional applications in foods, pharmaceuticals, and cosmetics. They possess antimicrobial, antioxidant, and cholesterol-regulating properties. Their effectiveness depends on the extraction method, but the potential health benefits are promising, justifying continued research to optimize their use. The lack of uniformity in experimental conditions and the presentation of results hampers effective comparisons between different wheat bran protein extraction methods, limiting the usefulness of existing reviews. To advance this field, it is essential to develop comparative studies that systematically and simultaneously evaluate multiple conventional and novel extraction methods under optimized and standardized conditions. Promising methods such as ultrasound-assisted extraction, whose potential has been identified but not yet exhaustively evaluated for wheat bran proteins, require further investigation. Future research should also consider the impact of extraction methods on protein structure and functional properties and their environmental viability.

CRediT authorship contribution statement

René Renato Balandrán-Quintana: Writing – original draft, Visualization, Investigation, Conceptualization. **Ana María Mendoza-Wilson:** Writing – review & editing, Investigation.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

No data was used for the research described in the article.

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