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Critical evaluation of the discrepancy between whole and refined foods: nutritional implications

Miguel Ángel Caro Roldán [1], Briana Davahiva Gómez Ramírez [2], Ana María Narváez Rivas [2]

[1] Grupo de Investigación Gestión de Servicios de Alimentación y Nutrición a Colectividades, Escuela de Nutrición y Dietética, Universidad de Antioquia, Medellín- Colombia. E-mail: miguel.caro@udea.edu.co

[2] Grupo de investigación en Alimentación y Nutrición Humana; Escuela de Nutrición y Dietética; Universidad de Antioquia; Medellín-Colombia. E-mail: briana.gomez@udea.edu.co anam.narvaez@udea.edu.co

ABSTRACT

Background: Contemporary dietary guidelines increasingly promote whole foods due to their purported nutritional superiority, including essential micronutrients, phytochemicals, and dietary fiber. However, defining what constitutes whole grains and whole foods remains ambiguous, causing confusion among consumers and in the food industry. Inconsistencies in global definitions and regulations have resulted in discrepancies in labeling, making it difficult for consumers to make informed decisions. **Aims:** This review aims to elucidate the complexities surrounding whole foods, from their definitions to their nutritional impact. By examining global regulations and conducting a comparative analysis of whole and refined products, this study seeks to provide insights into the nutritional composition of these foods and their implications for consumer health. **Methods:** An exhaustive literature review was conducted to gather information on definitions, regulations, and the nutritional composition of whole grains and whole foods. Sources included bibliographic databases, international organizations, and technical reports. Additionally, nutritional composition analyses of commercial cereal-based products were performed, comparing nutritional label data with the United States Department of Agriculture food composition table. **Results:** Significant discrepancies in the definition and regulation of whole grains and whole foods worldwide were identified. Despite their perceived nutritional benefits, whole products exhibited comparable nutritional profiles, including fiber content, to refined counterparts. Variations in labeling practices and nutrient composition were observed across different countries and organizations. **Conclusion:** This study highlights the complexity and inconsistencies surrounding the definition and regulation of whole foods. Although often perceived as healthier options, the findings suggest that they do not always offer significant nutritional advantages over refined products, especially in terms of fiber content. Standardizing definitions and improving labeling practices are crucial steps to ensure that whole foods meet consumer expectations and contribute to healthier dietary choices.

Keywords: Dietary fiber, food labeling, food legislation, whole foods, whole grains.

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Corresponding authors: Caro Roldan Miguel Ángel
E-mail: miguel.caro@udea.edu.co / miguecaror@gmail.com
Tel: +41 (0) 78 980 2343

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1 Introduction

In the pursuit of a healthier lifestyle, whole foods have gained prominence in dietary guidelines due to their supposed richness in essential micronutrients, phytochemicals, and dietary fiber. However, the classification and regulation of whole grains present a complex global landscape. Whole grains, encompassing a diverse range of cereals and pseudo cereals from the *Poaceae* family, are defined by their composition: they retain the starchy endosperm, germ, aleurone, and bran after processing (European Commission, 2023; Van der Kamp et al., 2021).

The processing of grains, from cleaning to milling, significantly influences their nutritional profile and consumer appeal, aiming to improve stability, taste, and nutrient bioavailability (Oghbaei & Prakash, 2016). Despite their acknowledged health benefits, inconsistencies in the definition and regulation of whole foods have hindered clear labeling practices across countries and organizations. For instance, while the United States mandates a minimum of 50% whole grains by weight for products labeled as whole grain, Brazil imposes a less stringent requirement of 30% (Agencia Nacional de Vigilancia Sanitaria de Brasil, 2023; U.S. Department of Agriculture, 2024b).

The lack of a unified EU standard further complicates matters in Europe, where individual nations have established distinct criteria (FoodDrinkEurope, 2023). This regulatory mosaic not only challenges international trade but also confuses consumers seeking genuinely whole grain products. The proliferation of self-labeled "whole grain" products without consistent nutritional benefits exacerbates consumer confusion.

Beyond regulatory challenges, the health benefits of whole grains are well documented in scientific literature. Rich in fiber, vitamins, minerals, and bioactive compounds, whole grains are associated with improved gastrointestinal function, a reduced risk of chronic diseases such as cardiovascular diseases and type 2 diabetes, and potential protective effects against certain types of cancer (Fardet, 2010; Rahmani et al., 2020).

Of particular interest is their impact on the gut microbiome, where fermentable fibers serve as substrates for beneficial bacteria, promoting gut health and metabolic well-being (Tamura & Brumer, 2021; Zmora et al., 2019). The fermentation of these fibers produces short-chain fatty acids crucial for immune modulation, inflammation regulation, and energy metabolism (Koistinen et al., 2019).

However, discrepancies in the nutritional composition between whole and refined commercially available foods pose challenges. Recent comparisons have revealed variability in fiber content among products labeled as whole grain, calling into question the reliability of current labeling practices and consumer expectations (U.S. Department of Agriculture, 2024a). Additionally, some refined products achieve similar fiber content levels, blurring distinctions for consumers seeking optimal dietary choices.

This review aims to comprehensively address the complexities surrounding whole foods, including their definition, regulatory frameworks, health impacts, and nutritional composition compared to refined products. By examining global regulations, and comparative analysis with refined counterparts. This study seeks to provide insights into the nutritional value of whole grains and their implications for consumers. The ultimate goal is to foster informed consumer choices and advocate for standardized global regulations to ensure transparency and consistency in labeling practices, thereby maximizing the potential health benefits associated with whole grain consumption.

2 Methods

2.1 Literature review

An exhaustive search of the scientific literature related to whole grains and whole foods was conducted. The following sources were used:

Bibliographic Databases: PubMed, Scopus, and Web of Science were consulted to identify relevant scientific articles on definitions, nutritional composition, health impacts, and gut microbiome.

International Organizations: Documents and guidelines from the World Health Organization (WHO), the Pan American Health Organization (PAHO), the United States Department of Agriculture (USDA), the Brazilian National Health Surveillance Agency (ANVISA), and the Southeast Asia Public Health Nutrition Network (SEA-PHN) were reviewed to obtain information on definitions and regulations.

Technical Reports: Reports from entities such as the Healthgrain Forum and the Whole Grain Council were consulted to understand the characteristics and properties of whole grains.

2.2 Nutritional composition analysis

A comparative analysis of the nutritional composition of commercial cereal-based products, both whole and refined, was performed. The products analyzed included bread, rice, cookies, tortillas, pasta, and toast (toasted bread). Nutritional label data were collected for three versions of each product (whole and refined) and compared with the information contained in the United States Department of Agriculture (USDA) food composition table. Specifically, two versions of the mentioned foods listed under "Foundation foods" were reviewed. The derived information is presented per 100 grams of product.

3 Results

3.1 Definition and regulations of whole grains and whole foods

The definition of whole grains applies to plants from the *Poaceae* family, which includes cereals and pseudo cereals, all composed of the starchy endosperm, germ, and the outer layers of aleurone and bran (European Commission, 2023). Among the whole cereals and pseudo cereals are rice, wheat, barley, rye, corn, sorghum, millet, teff, triticale, canary seed, Job's tears, fonio, amaranth, quinoa, buckwheat, and wild rice (Van der Kamp et al., 2021).

These grains, whether intact or processed, must maintain the original proportions of their edible components after the removal of non-edible parts, such as husks and hulls (Van der Kamp et al., 2021). The processing of grains, which can include cleaning, removing non-edible parts, and dry and wet processing, is done to improve stability, taste, nutrient bioavailability, as well as to facilitate storage and consumption (Van der Kamp et al., 2021).

According to the Healthgrain Forum 2010 (Ross et al., 2017), whole grains meet these characteristics, maintaining the appropriate proportions of bran, endosperm, and germ, or losing up to 2% of the grain or 10% of the bran due to processing.

The definition of "whole grain" can vary by country and organization:

- In the United States, according to USDA regulations, a product must contain at least 50% whole grains to meet whole grain richness criteria, allowing other grains to be enriched, bran, or germinated (U.S. Department of Agriculture, 2024b). Additionally, the industry-backed Whole Grain Stamp (Du et al., 2022) establishes that whole foods must contain at least 8g of whole grain ingredients per labeled serving, while the American Heart Association defines whole foods as those rich in cereals and containing 1.1g of fiber per 10g of carbohydrates.
- In Brazil, the National Health Surveillance Agency requires that at least 30% of the product's ingredients by weight be whole grains, and that there be more whole grain ingredients than refined ones (Agencia Nacional de Vigilancia Sanitaria de Brasil, 2023). In 2020, the Whole Grains initiative reiterated that whole food must contain at least 50% whole grain ingredients by dry weight (Whole Grain Council, 2020).
- In Colombia, although there is no specific regulation for whole foods, claims of "excellent source of fiber" are allowed when a product contains more than 6 grams of fiber per 100 grams or meets 20% of the Daily Reference Value set at 28 grams for those over 4 years old and adults. Similarly, claims of "good source of fiber" are allowed for products providing 3 grams of fiber per 100 grams or meeting 10% of the reference value (Ministerio de Salud y Protección Social, 2021).
- In Europe, while there is no unified legal definition of whole grain or whole products at the EU level, individual countries like Austria, Belgium, Czech Republic, Denmark, Finland, Lithuania, Netherlands, Norway, Portugal, Spain, Sweden, and Switzerland have established their own national definitions for whole grain as an ingredient. These definitions are generally aligned but not harmonized across borders (FoodDrinkEurope, 2023). According to EU Regulation 1308/2013, whole grains are described as "grains from which only part of the extremity has been removed, regardless of the characteristics produced at each stage of milling" (European Parliament, 2013).
- In Asia and Oceania, a similar definition of whole grain has been adopted: "Whole grains shall consist of the intact, ground, cracked or flaked caryopsis, whose principal anatomical components—the starchy endosperm, germ, and bran—are present in the same relative proportions as they exist in the intact caryopsis." This definition, with slight variations in wording, has been accepted in countries such as Australia, China, Malaysia, New Zealand, Singapore, and Taiwan (Southeast Asia Public Health Nutrition Network, 2023).

3.2 Nutritional composition differences between commercial whole and refined foods

A market research study was conducted to examine the labeling of various cereal-based products such as bread, rice, cookies, tortillas, pasta, and toast, in both their whole and refined forms. In parallel, a comparison of these same products was made with the information contained in the U.S. food composition table, specifically in the traditional foods category (U.S. Department of Agriculture, 2024a).

The results of this review indicated no significant differences between the nutritional composition of commercial products and the data in the food composition table. In other words, the original data in the table remained consistent and applicable to the products under study. For a more detailed view of these similarities and differences, the caloric and macronutrient contributions of various cereal products, whether refined or whole, are presented in Table 1.

Examining the data in Table 1 revealed substantial variability, particularly concerning fiber content, which led to a more detailed analysis. For example, it was found that whole grain breads had fiber contributions ranging from 2.2 g to 6.1 g per 100 g of product. Similarly, whole grain cookies were observed to have a range of 3.5 g to 7.1 g of fiber per 100 g. These findings underscore that, even among products labeled as "whole grain," fiber intake can vary considerably, raising questions about the consistency of their classification.

It was also noted that, in some cases, the difference in fiber content between refined and whole products was not substantial. For instance, whole grain bread brands were identified as providing 2.2 g of fiber per 100 g, a figure

Table 1. Caloric values, macronutrient composition, and fiber content of whole-grain and refined products (100 g)

Food	Kcal	Protein (g)	TF (g)	SF (g)	MF (g)	PF (g)	Carb. (g)	DF (g)
Whole grain bread	244	8.9	2.2	0.0	0.0	1.1	48.9	2.2
	262	9.8	1.7	0.2	0.3	1.1	55.9	6.1
Refined bread	267	6.7	3.3	0.0	0.0	1.1	51.1	2.2
	266	8.9	3.3	0.7	0.6	1.6	49.4	2.7
Brown rice	122	2.7	1.0	0.3	0.4	0.4	25.4	1.6
White rice	161	2.3	2.1	0.7	1.1	0.0	32.5	1.6
	129	2.7	0.3	0.1	0.1	0.1	28.0	0.4
Whole grain cracker	482	7.1	20.4	3.3	5.0	11.8	20.4	3.5
	500	7.1	17.9	0.0	3.6	10.7	71.3	7.1
Refined cracker	438	6.3	25.0	3.1	6.3	12.5	50.0	0.0
	418	9.5	8.6	1.7	2.0	4.8	74.0	2.8
Whole grain tortillas	310	9.8	9.8	4.9	3.1	1.0	45.9	9.8
Refined tortillas	306	8.2	8.0	2.9	1.8	2.3	49.4	3.5
Whole grain pasta	148	6.0	1.7	0.2	0.2	0.6	29.9	3.9
	159	5.8	1.5	0.2	0.2	0.6	31.5	4.6
Pasta	157	5.8	0.9	0.2	0.1	0.3	30.6	1.8
	132	4.5	1.0	0.2	0.1	0.3	25.5	1.2
Whole grain toast	306	16.3	4.1	0.9	2.0	0.7	51.2	7.5
	305	9.2	5.9	0.9	1.3	3.2	56.4	6.7
Refined toast	299	11.1	3.8	1.3	0.9	0.9	55.2	1.9
	313	13.0	4.3	1.0	1.0	1.7	55.8	4.7

TF= total fat; SF= saturated fat; MF= monounsaturated fat; PF= polyunsaturated fat; Carb= carbohydrates; DF= dietary fiber Average of three samples of commercial products compared with three products from the U.S. Department of Agriculture food composition table (2024a). USDA Food Composition Database. USDA Food Composition Database. https://fdc.nal.usda.gov/.

identical to that found in refined bread (2.2 g/100 g). Similarly, for brown rice and white rice, it was found that brown rice contained 1.6 g/100 g, an amount that some refined rice also achieved (1.6 g/100 g).

Regarding the quality of being a good source of fiber, that is, providing more than 10% of the dietary recommendation per 100 g, whole grain tortillas and whole grain pasta stood out, as they were also positioned as good sources of protein, providing more than 10% of the daily recommendation for this component in both varieties (whole and refined). These results are detailed in Table 2.

On the other hand, when considering the contribution of micronutrients, Table 2 presents the percentage contribution of cereals and cereal-based products to the dietary recommendations for micronutrients, fiber, and protein for adults, evaluating which could be considered a good or excellent source of different nutrients. It was observed that none of the cereals or cereal-based products stood out as an excellent source of any nutrient, implying that they did not

	Prot. (g)	DF (g)	Ca (mg)	Fe (mg)	Na (mg)	Zn (mg)	Vit E (mg)	Thiam. (mg)	Ribof. (mg)	Niac. (mg)	Piridox. (mg)	Folate (ug)
Whole grain bread	9%	7%	4%	8%	11%	7%	3%	7%	6%	9%	10%	4%
Refined bread	8%	4%	6%	9%	12%	3%	1%	12%	10%	12%	3%	1%
Brown rice	5%	6%	0%	3%	10%	6%	2%	15%	6%	17%	9%	2%
White rice	5%	4%	1%	3%	6%	4%	0%	7%	1%	6%	7%	8%
Whole grain cracker	3%	5%	0%	4%	11%	2%	5%	11%	6%	5%	2%	6%
Refined cracker	4%	1%	2%	5%	10%	2%	3%	15%	10%	10%	2%	8%
Whole grain tortillas	6%	11%	7%	4%	9%	5%	3%	17%	7%	9%	6%	7%
Refined tortillas	5%	4%	4%	5%	11%	1%	0%	13%	7%	9%	1%	7%
Whole grain pasta	12%	15%	1%	8%	6%	11%	2%	14%	8%	20%	7%	5%
Pasta	10%	5%	1%	4%	3%	5%	1%	13%	7%	7%	4%	10%
Whole grain toast	8%	8%	2%	5%	7%	5%	2%	8%	6%	10%	5%	4%
Refined toast	7%	4%	3%	6%	9%	3%	1%	12%	9%	11%	3%	6%

Prot.= protein; DF= dietary fiber; RDA= Recommended Dietary Allowance

< 5% RDA; Between 5-10% RDA; Between 11-15% RDA

Good Source (>10% in Prot. and DF / >15% in vitamins and minerals)

Excelent Source (>20% in Prot. and DF / >30% in Vitamins and Minerals)

Table 2. Percentage of micronutrient intake of whole-grain and refined products with respect to dietary recommendations

provide more than 30% of the dietary recommendation per 100 g of the corresponding micronutrient.

Some products, such as brown rice, refined cookies (possibly due to fortifications), and whole grain tortillas, were considered good sources of thiamine, while brown rice and pasta were identified as good sources of niacin, providing more than 15% of the dietary recommendation per 100 g of the reviewed micronutrient. Most of the other analyzed products offered between 5% and 10% of the dietary recommendations.

4 Discussion

The present study underscores the challenges associated with establishing standardized definitions for whole grains and whole grain products. Consequently, the nutritional composition of many formulated products may not fully realize the potential health benefits attributed to whole grains.

The definition and regulatory framework surrounding whole grains encompass a complex global landscape. Originating from the *Poaceae* family, whole grains comprise the intact or processed forms of cereals and pseudo cereals, retaining their endosperm, germ, aleurone, and bran layers. While this fundamental structure is consistent, the specific definitions and regulatory requirements for whole grains vary considerably across jurisdictions (European Commission, 2023; Van der Kamp et al., 2021). The definitions of "whole grain" vary significantly around the world. For instance, the United States mandates a minimum of 50% whole grain content by weight, whereas Brazil requires only 30%. (Brazilian National Health Surveillance Agency, 2023; U.S. Department of Agriculture, 2024b). Identical discrepancies exist in Europe, Asia, and Oceania, hindering international trade and consumer decision-making. (FoodDrinkEurope, 2023; Southeast Asia Public Health Nutrition Network, 2023). The absence or inconsistency of whole grain food labeling regulations, compounded by the influence of water content on product weight, further complicates the accurate assessment of whole grain content. Consequently, evaluating whole grain content on a dry weight basis, adjusted for moisture content, is often considered a more reliable approach (Van der Kamp et al., 2021).

The inconsistent regulatory landscape has resulted in a proliferation of products labeled as whole grain. In 2023, over 13,000 products worldwide carried the whole grain label, underscoring their popularity and the need for clear and standardized guidelines to assist consumer decision-making. (Whole Grain Council, 2023).

The proliferation of whole grain-labeled products has heightened consumer awareness of their nutritional benefits in a healthy diet, although it has also created difficulties for consumers to easily select appropriate products (Ross et al., 2017). However, the abundance of such products, estimated at over 13,000 globally in 2023 (Whole Grain Council, 2023), underscores the challenge consumers face in discerning products that genuinely deliver significant whole grain content (Ross et al., 2017). It is crucial to distinguish between the terms "whole grain" and "whole food." While the former specifically refers to intact cereal or pseudo cereal grains, the latter encompasses a broader range of minimally processed foods.

Whole grains have garnered significant scientific interest due to their potential health benefits attributed to their rich content of fiber, micronutrients, and bioactive compounds. These constituents have been associated with improved gastrointestinal health and reduced risk of chronic diseases including cardiovascular disease, type 2 diabetes, and certain cancers (Fardet, 2010; Rahmani et al., 2020). Notably, whole grains exert a beneficial influence on the gut microbiome, promoting diverse microbial populations and stimulating the production of short-chain fatty acids crucial for metabolic health (Tamura & Brumer, 2021; Zmora et al., 2019).

Whole grains and whole foods have garnered significant scientific interest due to their potential health benefits attributed to their fiber, micronutrients, and bioactive compounds, including minerals, vitamins, polyphenols, and alkylresorcinols (Fardet, 2010). These constituents have been associated with multiple beneficial effects, such as increasing satiety, improving bowel transit, reducing glycemic response, increasing fecal bulk, and promoting antioxidant and anticancer properties (Fardet, 2010). Therefore, a regulatory guideline is important, as the way a product is manufactured can vary. According to Botelho et al. (2017), formulation process, rather than processing itself, significantly influences the nutritional value of whole grain products. The addition of sodium, sugar, and fat during formulation can diminish the overall nutritional profile, while processing methods generally preserve the inherent nutritional benefits of whole grains.

A critical aspect of the relationship between whole grains and health lies in their impact on the gut microbiome. The insoluble and fermentable fiber content of whole grains influences gastrointestinal transit time, and stool weight. In the colon, these fibers can serve as substrates for microbial hydrolytic enzymes, influencing the composition and diversity of the gut microbiome (Tamura & Brumer, 2021). These fibers serve as substrates for the diverse microbiota residing in the colon, estimated to comprise over 2,500 species. The composition of this microbiome, influenced by genetic, dietary, and environmental factors, is crucial for overall health (Zmora et al., 2019).

Diet significantly influences the composition of the gut microbiome. Fiber-rich diets, particularly those incorporating whole grains, have been shown to promote microbial diversity within the gastrointestinal tract (Koistinen et al., 2019). The fermentation of dietary fibers and resistant starches in the colon yields short-chain fatty acids, which play a critical role in energy metabolism, glucose homeostasis, inflammation regulation, and immune function (Koistinen et al., 2019).

Whole grains have been implicated in cancer prevention, particularly for colorectal and breast cancers. Their fiber content is believed to reduce intestinal transit time, limit carcinogen exposure, and modulate the gut microbiota, thereby exerting protective effects (Tieri et al., 2020). The synergistic interplay of macronutrients, micronutrients, and phytochemicals within whole grains contributes to these benefits (Koistinen et al., 2019).

Whole grain consumption has been associated to a reduced incidence and mortality from cardiovascular diseases and type 2 diabetes (Tosh & Bordenave, 2020). These grains have demonstrated beneficial effects on insulin resistance, glucose metabolism, and inflammatory markers (Rahmani et al., 2020). While fiber is a key contributor to these health outcomes, other components within whole grains also play a role in their cardioprotective effect (Seal et al., 2021).

Dose-response studies have established a clear correlation between whole grain intake and reduced risk of coronary heart disease, cardiovascular diseases, total cancer, and all-cause mortality (Aune et al., 2016). A daily intake of 30 – 45 g of whole grains has been associated with significant reduction of type 2 diabetes incidence and cardiovascular and cerebrovascular diseases (McRae, 2017). Whole grain consumption (28 – 30 g/day) has also been observed to reduce total and LDL cholesterol. However, the impact on gastric cancer prevention remains inconclusive (McRae, 2017).

While observational studies have consistently shown a positive association between whole grain consumption and reduced disease risk, intervention study results are less conclusive (Jonnalagadda et al., 2011). However, it has been suggested that considering bran, germ, and fiber along with whole grains provides evidence of a protective effect on cardiovascular diseases (Jonnalagadda et al., 2011). Whole grain and whole food consumption have been linked to protective health effects, such as reduced risk of cancer, cardiovascular diseases, and type 2 diabetes. These benefits are attributed to the presence of fiber, bioactive compounds, and their impact on the gut microbiome. Although some intervention studies have yielded inconsistent results, evidence suggests that whole grains can play a crucial role in a healthy diet to prevent diseases and promote overall well-being.

Despite the recognized health benefits of whole grains, inconsistencies in product formulation and labeling have hindered consumer understanding. While numerous products carry whole grain claims, the actual whole grain content can vary significantly. For instance, the fiber content in whole grain breads and cookies demonstrates this variability, highlighting the challenge consumers face in making informed choices. Differentiating between the terms "whole grain" and "whole food" is essential, as the former specifically refers to intact cereal grains while the latter encompasses a broader range of minimally processed foods (U.S. Department of Agriculture, 2024a). Moreover, some refined products approach similar fiber levels, as shown in our results, thereby obscuring clear distinctions for consumers seeking nutritional benefits. Micronutrient contribution also varies across products, with few meeting recommended intake levels. (U.S. Department of Agriculture, 2024a). While primary processing inevitably impacts the nutritional quality of cereals, as noted by Oghbaei et al. (2016), excessive processing can diminish nutritional value and emphasizing the consumption of whole foods. The current study highlights the challenge of defining "whole food" due to the potential for refined products to nutritionally resemble whole grain counterparts. On the other hand, it is also timely to analyze what Thielecke et al. (2020) mention, highlighting that cereal processing is essential for human consumption, as we are not equipped to survive on raw grains.

While observational studies systematically relate whole grain consumption with reduced disease risk, the outcomes of intervention studies offer mixed results. Nevertheless, the preponderance of evidence suggests that incorporating whole grains into a healthy diet can significantly contribute to overall health and disease prevention (Aune et al., 2016; Jonnalagadda et al., 2011).

5 Conclusion

The diversity of definitions and regulatory frameworks surrounding whole foods highlights the inherent complexity and challenges in achieving consistent labeling and consumer comprehension on a global scale. Despite these difficulties, scientific evidence robustly supports the health benefits of whole grains, primarily attributed to their rich content of fiber, essential nutrients, and bioactive compounds. These components are instrumental in promoting improved gut health, reducing the risk of chronic diseases such as cardiovascular conditions and type 2 diabetes and potentially offering protective effects against certain types of cancer.

However, discrepancies in the nutritional profiles of products labeled as whole grains underscore the urgent request for standardized definitions and rigorous labeling practices to facilitate informed consumer choices. Although whole grain products are often marketed for their health benefits, this study reveals that they may not consistently offer substantial nutritional advantages over refined products, particularly concerning fiber content. This may inconsistency may be attributed to variations in the processing and formulation of whole grain products, where some may not retain a significant proportion of their original components, such as bran and germ.

While observational studies consistently demonstrate the benefits of whole grain consumption, intervention studies yield mixed results, indicating a need for further research to clarify specific mechanisms and determine optimal doses for health benefits.

Looking forward, efforts should prioritize the harmonization of global regulations, enhanced transparency in labeling, and the promotion of education regarding the nutritional differences between whole grains and refined products. By addressing these issues, stakeholders can more effectively support public health initiatives and empower individuals to integrate whole grains into their diets, thereby maximizing their potential health benefits.

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