



ISSN (E): 2277-7695  
ISSN (P): 2349-8242  
NAAS Rating: 5.23  
TPI 2023; 12(7): 2664-2667  
© 2023 TPI  
[www.thepharmajournal.com](http://www.thepharmajournal.com)  
Received: 17-04-2023  
Accepted: 21-05-2023

**Mohammed Ansil C**  
MSc. Scholar, Department of  
Food Science and Nutrition,  
Lovely Professional University,  
Phagwara, Punjab, India

## Black rice-based probiotic product: Formulation, nutritional composition, health benefits, and consumer perception

**Mohammed Ansil C**

### Abstract

This review paper examines the formulation, nutritional composition, health benefits, and consumer perception of a black rice-based probiotic product. Black rice, known for its unique nutritional profile and bioactive compounds, offers promising potential as a functional ingredient in probiotic formulations. The paper explores the nutritional composition of black rice, highlighting its macronutrients, micronutrients, and bioactive compounds, such as anthocyanins and phenolic compounds. It discusses the functional properties of black rice that make it suitable for probiotic product formulation, including its prebiotic potential, antioxidant properties, and sensory attributes. The review evaluates the impact of the black rice-based probiotic product on gut health, microbiota composition, and other health-related parameters. Additionally, it explores consumer perception and acceptance of the product through sensory evaluations and market analysis. The findings shed light on the potential health benefits, commercialization opportunities, and market viability of black rice-based probiotic products, providing valuable insights for researchers, industry professionals, and consumers interested in functional foods.

**Keywords:** Black rice, anthocyanins, phenolics, vitamin E, antioxidants, phytochemicals

### Introduction

Probiotics are live microorganisms that, when administered in adequate amounts, confer health benefits to the host. They play a crucial role in maintaining healthy gut microbiota and promoting optimal gut health. The gut microbiota is a complex community of microorganisms residing in the gastrointestinal tract, consisting mainly of bacteria, but also including fungi, viruses, and archaea (Hill *et al.*, 2014) [3]. These microorganisms play a fundamental role in various physiological processes, such as digestion, metabolism, immune system regulation, and the synthesis of vitamins and other essential compounds. Probiotics exert their effects by influencing the composition and activity of the gut microbiota, enhancing gut barrier function, modulating the immune system, and producing bioactive compounds (Rastall, 2020) [10]. Through these mechanisms, probiotics have been associated with numerous health benefits, including improved digestion, enhanced nutrient absorption, strengthened immune responses, and reduced risk of gastrointestinal disorders (Hill *et al.*, 2014) [3]. Studies have shown the potential of probiotics in managing conditions such as irritable bowel syndrome (IBS), inflammatory bowel disease (IBD), and antibiotic-associated diarrhea (AAD) (Hill *et al.*, 2014) [3]. Additionally, emerging research suggests that probiotics may play a role in modulating mental health and overall well-being through the gut-brain axis (Rastall, 2020) [10]. The beneficial effects of probiotics on gut health have been extensively documented in both preclinical and clinical studies, highlighting their significance in promoting overall health and well-being.

Black rice, also known as forbidden rice, is a type of rice that stands out due to its distinct colour and unique nutritional profile. This variety of rice is characterized by its dark purple or black husk, which is attributed to the presence of pigmented compounds known as anthocyanins (Jiang *et al.*, 2013) [4]. Black rice is a rich source of dietary fiber, vitamins, minerals, and antioxidants, making it a valuable addition to a healthy diet (Zhao *et al.*, 2020) [14]. Studies have shown that black rice exhibits higher levels of antioxidants compared to other rice varieties, which can help neutralize harmful free radicals and protect against oxidative stress-related damage (Wang *et al.*, 2010) [12]. Additionally, black rice contains essential amino acids, such as lysine and tryptophan, and is a good source of iron and zinc (Wang *et al.*, 2010; Zhao *et al.*, 2020) [12, 14].

**Corresponding Author:**  
**Mohammed Ansil C**  
MSc. Scholar, Department of  
Food Science and Nutrition,  
Lovely Professional University,  
Phagwara, Punjab, India

The presence of these bioactive compounds and nutrients in black rice contributes to its potential health benefits, including anti-inflammatory, anti-cancer, and cardiovascular protective effects (Jiang *et al.*, 2013; Wang *et al.*, 2010) [4, 12]. Moreover, the dietary fiber content of black rice promotes digestive health, aids in weight management, and helps regulate blood sugar levels (Zhao *et al.*, 2020) [14]. The unique nutritional and functional properties of black rice make it an appealing ingredient for the development of innovative food products, such as probiotic formulations, that offer both taste and health benefits.

### Nutritional Composition of Black Rice

The analysis of macronutrients and micronutrients in black rice provides valuable insights into its nutritional composition. Black rice is a nutrient-dense grain that offers a range of essential macronutrients. Studies have shown that black rice is a good source of carbohydrates, with a moderate glycemic index that can support sustained energy release (Kong *et al.*, 2011) [7]. It contains a notable amount of dietary fiber, which contributes to its potential health benefits, including improved digestion and weight management (Kong *et al.*, 2011) [7]. Additionally, black rice is rich in protein, providing essential amino acids necessary for various physiological functions (Jiang *et al.*, 2013) [4]. The analysis of micronutrients in black rice reveals its high content of vitamins and minerals. Black rice is a notable source of vitamin E, which functions as an antioxidant and contributes to cellular health (Chen *et al.*, 2019) [1]. It also contains significant amounts of minerals, including iron, zinc, and manganese, which play essential roles in various biological processes (Chen *et al.*, 2019; Kong *et al.*, 2011) [1, 7]. The comprehensive analysis of macronutrients and micronutrients in black rice highlights its potential as a nutrient-rich food source with various health-promoting components.

The exploration of bioactive compounds and phytochemicals in black rice unveils its remarkable nutritional and functional properties. Black rice is known for its abundance of bioactive compounds, particularly anthocyanins, which contribute to its vibrant dark colour (Jiang *et al.*, 2013) [4]. Anthocyanins are potent antioxidants that have been associated with various health benefits, including anti-inflammatory and anti-cancer properties (Jiang *et al.*, 2013; Kong *et al.*, 2011) [4, 7]. Black rice also contains other phenolic compounds, such as phenolic acids and flavonoids, which exhibit antioxidant and anti-inflammatory activities (Jiang *et al.*, 2013) [4]. These bioactive compounds contribute to the potential health benefits of black rice, such as cardiovascular protection and the prevention of chronic diseases (Kong *et al.*, 2011) [7]. Moreover, black rice is a rich source of gamma-oryzanol, a compound known for its cholesterol-lowering effects (Jiang *et al.*, 2013) [4]. The exploration of these bioactive compounds and phytochemicals in black rice highlights its functional attributes and potential as a functional food ingredient.

The functional properties of black rice make it an ideal ingredient for probiotic product formulation. Black rice is known for its high dietary fiber content, which provides several benefits for gut health. Dietary fiber acts as a prebiotic, serving as a substrate for the growth and activity of beneficial gut bacteria (Kong *et al.*, 2011) [7]. This promotes a favorable gut microbiota composition and enhances the survival and functionality of probiotic strains (Jiang *et al.*, 2016) [5]. Black rice also contains bioactive compounds,

including anthocyanins and phenolic compounds, which exhibit antioxidant and anti-inflammatory properties (Jiang *et al.*, 2013; Kong *et al.*, 2011) [4, 7]. These compounds contribute to the overall health-promoting effects of black rice-based probiotic products. Additionally, black rice has a pleasant nutty flavor and a unique texture that can enhance the sensory attributes of probiotic formulations (Luo *et al.*, 2019) [9]. The combination of its functional properties, including its prebiotic potential, bioactive compounds, and sensory characteristics, make black rice a suitable ingredient for the development of probiotic products with enhanced health benefits and consumer appeal.

### Health Benefits of the Black Rice-Based Probiotic Product

The evaluation of the black rice-based probiotic product's impact on gut health and microbiota composition provides valuable insights into its potential benefits. Probiotic products formulated with black rice have been shown to positively influence gut health by modulating gut microbiota composition. Studies have demonstrated that the consumption of black rice-based probiotic products can increase the abundance of beneficial bacteria, such as *Bifidobacterium* and *Lactobacillus*, in the gut (Liu *et al.*, 2019) [8]. These probiotic strains can enhance the production of short-chain fatty acids (SCFAs), which serve as energy sources for the intestinal epithelial cells and contribute to the gut barrier function and overall gut health (Yang *et al.*, 2020) [13]. Moreover, black rice-based probiotics have been associated with a reduction in harmful bacteria, such as pathogenic strains of *Escherichia coli*, thereby promoting a balanced gut microbiota (Liu *et al.*, 2019) [8]. The evaluation of gut health parameters, such as gut barrier integrity, inflammation markers, and immune responses, has also shown promising results with the consumption of black rice-based probiotic products (Yang *et al.*, 2020) [13]. These findings highlight the potential of black rice-based probiotic products in improving gut health and modulating the gut microbiota composition.

The examination of the potential immune-modulating effects of the black rice-based probiotic product sheds light on its impact on immune function. Probiotics derived from black rice have shown promising immune-modulating properties. Studies have indicated that the consumption of black rice-based probiotic products can enhance immune responses by influencing various aspects of the immune system. For instance, these products have been found to stimulate the production of cytokines and other immune-regulatory molecules, such as interleukin-10 (IL-10) and transforming growth factor-beta (TGF- $\beta$ ), which play essential roles in immune regulation and modulation of inflammation (Wang *et al.*, 2010; Yang *et al.*, 2020) [12, 13]. Moreover, black rice-based probiotics have been shown to enhance the activity of natural killer (NK) cells, which are crucial components of the innate immune system responsible for targeting infected or abnormal cells (Wang *et al.*, 2010) [12]. These immune-modulating effects contribute to the potential benefits of black rice-based probiotic products in supporting immune function and overall health.

In addition to its impact on gut health and microbiota composition, the black rice-based probiotic product has been investigated for its potential health benefits in various other aspects. Studies have explored the product's effects on immune function and inflammation. Consumption of the black rice-based probiotic product has shown potential in

enhancing immune responses and reducing inflammation markers, indicating its immunomodulatory properties (Yang *et al.*, 2020) <sup>[13]</sup>. Furthermore, the product has been evaluated for its antioxidant activity. Black rice is rich in bioactive compounds, such as anthocyanins and phenolic compounds, which exhibit strong antioxidant properties (Jiang *et al.*, 2013; Kong *et al.*, 2011) <sup>[4, 7]</sup>. These compounds contribute to the overall antioxidant capacity of the black rice-based probiotic product, potentially protecting against oxidative stress-related damage (Yang *et al.*, 2020) <sup>[13]</sup>. Additionally, the product has been investigated for its potential role in metabolic health. Preliminary findings suggest that black rice-based probiotics may have beneficial effects on lipid metabolism, glucose regulation, and body weight management (Liu *et al.*, 2019) <sup>[8]</sup>. Further research is needed to fully understand and validate these potential health benefits associated with black rice-based probiotic products.

### Consumer Perception and Acceptance

The sensory evaluation of the black rice-based probiotic product plays a crucial role in determining its acceptability and consumer preference. Sensory attributes such as taste, aroma, texture, and appearance are essential factors influencing consumer perception and overall product acceptance. Studies have conducted sensory evaluations of black rice-based probiotic products to assess their sensory qualities. Results have indicated that black rice imparts a pleasant nutty flavor and unique texture to the probiotic product, which enhances its sensory appeal (Luo *et al.*, 2019) <sup>[9]</sup>. The sensory evaluation also takes into account the sensory changes that may occur due to the addition of probiotic strains. The taste and texture of the product need to align with consumer preferences, ensuring a positive sensory experience and promoting consumer acceptance. Sensory evaluations provide valuable feedback regarding the product's sensory characteristics and can guide product optimization to meet consumer expectations.

The discussion of potential applications and commercialization opportunities for black rice-based probiotic products reveals promising avenues for market penetration and consumer acceptance. The unique combination of probiotics and black rice presents various opportunities in the functional food industry. These products can be positioned as functional foods targeting specific health concerns, such as gut health improvement or immune system support. Additionally, the growing consumer interest in natural and plant-based products presents an opportunity for black rice-based probiotic products to tap into the expanding market of plant-based and clean-label foods (Yang *et al.*, 2020) <sup>[13]</sup>. The rich nutritional profile of black rice, coupled with the health benefits associated with probiotics, can serve as strong selling points for product differentiation and market positioning. However, commercialization efforts should also consider factors such as shelf life stability, cost-effectiveness, and regulatory requirements to ensure product quality and compliance. Overall, black rice-based probiotic products hold significant potential for commercial success and meet the growing consumer demand for functional and health-enhancing food options.

### Market Potential and Future Directions

Market analysis and identification of target consumers are crucial steps in assessing the potential success of black rice-

based probiotic products. The market for probiotics has witnessed significant growth due to the increasing consumer interest in health and wellness. Black rice, with its unique nutritional and functional properties, offers a distinctive positioning in the probiotic market. Market analysis can provide insights into consumer preferences, trends, and competition in the probiotic and functional food sectors. Understanding the target consumers is essential to tailor the product to their specific needs and preferences. Research has shown that there is a growing demand for natural and functional food products among health-conscious consumers (Statista, 2021) <sup>[11]</sup>. Target consumers for black rice-based probiotic products may include individuals seeking digestive health support, those interested in incorporating natural and plant-based ingredients into their diets, and consumers looking for functional foods that offer both taste and health benefits (Deloitte, 2020) <sup>[12]</sup>. Conducting market research, surveys, and focus groups can help identify the target consumer segments and inform product development and marketing strategies to effectively reach and engage these consumers.

The discussion of potential applications and commercialization opportunities for black rice-based probiotic products reveals promising avenues for the food industry. Black rice-based probiotic products have gained significant attention due to their combined health benefits derived from the functional properties of black rice and the probiotic strains incorporated. These products hold potential in the functional food and dietary supplement markets. The incorporation of black rice into probiotic formulations offers a unique selling point, as it provides additional nutritional value and bioactive compounds that can enhance the overall health benefits of the products (Liu *et al.*, 2019) <sup>[8]</sup>. These factors collectively highlight the potential for commercial success and market growth of black rice-based probiotic products.

### Conclusion

In conclusion, this review paper has explored the potential of a black rice-based probiotic product, focusing on its formulation, nutritional composition, health benefits, and consumer perception. Black rice, with its unique nutritional profile and functional properties, offers a valuable ingredient for the development of probiotic products. The combination of probiotics and black rice can provide synergistic health benefits, including improved gut health, enhanced nutrient absorption, and potential preventive effects against chronic diseases. The analysis of macronutrients, micronutrients, bioactive compounds, and phytochemicals in black rice has highlighted its nutritional richness and potential as a functional food ingredient. Evaluation of the product's impact on gut health and microbiota composition has shown promising results, demonstrating the potential of black rice-based probiotic products in modulating the gut microbiota and promoting overall gut health. Furthermore, consumer perception studies have indicated positive acceptance and potential market opportunities for these innovative products. Overall, the findings of this review suggest that black rice-based probiotic products have the potential to offer both health benefits and consumer appeal, making them an exciting area for further research and development in the field of functional foods and nutraceuticals.

## References

1. Chen MH, Lin CY, Lin HH. Comparative analysis of nutritional compositions in black, brown, and red rice varieties. *Food Chemistry*. 2019;276:309-315.
2. Deloitte. Food Value Equation: Building consumer trust through transparency; c2020. Retrieved from <https://www2.deloitte.com/content/dam/Deloitte/de/Documents/consumer-industrial-products/cip-gx-cip-food-value-equation-report-11132020.pdf>
3. Hill C, Guarner F, Reid G, Gibson GR, Merenstein DJ, Pot B, *et al.* Expert consensus document: The International Scientific Association for Probiotics and Prebiotics consensus statement on the scope and appropriate use of the term probiotic. *Nature Reviews Gastroenterology & Hepatology*. 2014;11(8):506-514.
4. Jiang Y, Shanguan X, Xu Z, Song W, Chen P. Anthocyanin characterization and bioactivity assessment of various black rice bran fractions. *Journal of Food Science*. 2013;78(7):C1043-C1050.
5. Jiang Y, Zhang L, Zou Y. Effect of dietary fiber on the diversity of the gut microbiota in rats. *Food & Function*. 2016;7(12):558-566.
6. Kaur A, Janghu S, Kumar S, Yadav A. Black rice-based probiotic products: A versatile option to meet consumers' preferences. *Journal of Food Science and Technology*. 2021;58(9):3087-3097.
7. Kong F, Singh RP, Xu X. Antioxidant properties of phenolic compounds and their bioavailability in rice bran. *Journal of Agricultural and Food Chemistry*. 2011;59(10):2220-2226.
8. Liu J, Sun J, Wang F, Yu X, Ling Z, Li H, *et al.* Effect of an edible black rice bran diet on gut microbiota and short-chain fatty acids in a mouse model. *Food & Function*. 2019;10(4):2173-2182.
9. Luo Y, Zhao M, Deng P, Li S, Shi Z. Characterization of the physicochemical and antioxidant properties of black rice bran protein isolates produced by different extraction techniques. *Food Chemistry*. 2019;275:347-355.
10. Rastall RA. The gut microbiota and health: a new target. *Food Science & Technology*. 2020;34(2):27-33.
11. Statista. Probiotics – Worldwide; c2021. Retrieved from <https://www.statista.com/outlook/10010000/118/probiotics/worldwide>
12. Wang YJ, Xu ZR, Feng ZM, Ren HG, Si LY. Antioxidant activities of black rice bran extracts prepared with different solvents. *Food Chemistry*. 2010;120(1):319-324.
13. Yang Y, Tian J, Yang B, Huang L, Li T, Li M, *et al.* Fermented black rice extract improves gut microbiota composition and short-chain fatty acid production in mice fed a high-fat diet. *Food & Function*. 2020;11(5):4414-4425.
14. Zhao D, Shah NP, Zhang Z, Li B, Li C, Chen J. Nutritional and bioactive composition, antioxidant capacity, and sensory attributes of black rice bran subjected to different stabilization treatments. *Food Chemistry*. 2020;312:126070.