

# *Broken Rice as a Sustainable Food Resource: Composition, Applications, and Valorization Pathways*

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**OPEN ACCESS**

**Keywords**

Bioprocessing, Sustainable utilization, Agri-food waste valorization, Byproducts

*How to cite this article:*

Wagh, M. D., Roy, T., Gore, V. B. and Kundan. 2026. Broken Rice as a Sustainable Food Resource: Composition, Applications, and Valorization Pathways. *Vigyan Varta* 7 (01): 58-60.

## **ABSTRACT**

Broken rice, comprising small and fractured kernels generated during rice milling, is a major byproduct of the rice processing industry. Owing to its lower commercial value compared to whole rice grains, broken rice is often diverted from the human food chain to low-value applications such as animal feed and bioenergy production. However, its compositional similarity to whole rice and favorable functional properties offer significant potential for value addition. This article reviews recent advances in the composition, food applications, protein recovery, fermentation-based valorization, and sustainability aspects of broken rice, while highlighting key challenges and future research directions for its efficient utilization.

## **INTRODUCTION**

**B**roken rice consists of grain fragments generated at various stages of the rice milling process, including dehusking, polishing, and handling. Owing to its fragmented nature, broken rice commands a

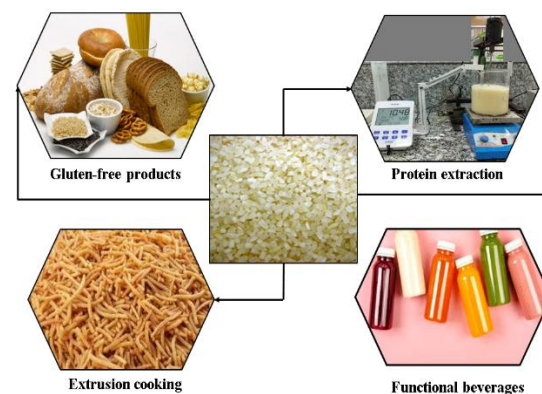
substantially lower market price reported to be nearly one-fifth that of whole rice kernels which has led to its predominant utilization in non-food sectors such as animal feed and bioenergy production. This redirection away

from human consumption represents a significant loss of both nutritional value and economic potential, particularly in regions where rice is a dietary staple. In the context of increasing global demand for affordable, plant-based, and sustainable food ingredients, the development of high value-added products from broken rice has gained considerable attention as a strategy to enhance resource efficiency and support food system sustainability (Roy *et al.*, 2025). From a compositional perspective, broken rice exhibits a macronutrient profile comparable to that of whole milled rice, with a predominance of starch, moderate levels of protein, low lipid content, and minimal antinutritional factors (Phillips *et al.*, 2024). This article reviews recent advances in the composition, food applications, sustainability aspects of broken rice, while highlighting key challenges and future research directions for its efficient utilization.

### Food and ingredient applications

Owing to its nutritional equivalence to whole rice and considerable functional versatility, broken rice has been extensively investigated for a wide range of food applications (Fig. 1). It is most commonly milled into rice flour and incorporated into traditional foods as well as value-added products such as fibre-enriched noodles, gluten-free bakery items, and instant food mixes, where it has demonstrated satisfactory cooking performance, textural quality, and consumer acceptability. The absence of gluten and the neutral flavor profile of broken rice flour further enhance its suitability for specialized dietary formulations. In addition, broken rice serves as an effective raw material for extrusion cooking, enabling the production of expanded snacks and breakfast cereals with desirable structural and sensory attributes. These extruded products are often fortified with bioactive compounds, natural pigments, or functional ingredients to improve their nutritional profile. Beyond solid

food applications, recent studies have explored the use of broken rice as a base for functional beverages, where optimized homogenization, enzymatic treatment, and thermal processing conditions have been shown to preserve antioxidant activity and enhance bioactive compound stability. Furthermore, protein-rich fractions obtained from broken rice, including co-products generated during bioethanol production, have demonstrated promising functional properties and nutritional quality when incorporated into cereal-based blends. These protein fractions offer a low-cost, hypoallergenic, and nutritionally balanced plant protein source, supporting their growing relevance in plant-based and vegan food formulations (Chen *et al.*, 2022).



**Fig. 1. Application of broken rice**

### Challenges and research gaps

Despite these advances, large-scale food utilization of broken rice is constrained by variability in raw material quality, including differences in bran content and milling degree. The application of broken rice in beverage development has been minimally explored, as products derived from it often face issues of limited shelf life and increased risk of microbial spoilage. Moreover, many protein extraction, modification, and fermentation-based valorization strategies reported in the literature have been demonstrated primarily at the laboratory or pilot scale, necessitating further validation under industrial conditions.

Comprehensive techno-economic assessments, including cost-benefit analyses, energy requirements, and scalability evaluations, are essential to determine their commercial feasibility. In addition to technical barriers, regulatory compliance presents a significant challenge, particularly with respect to food safety assurance, allergen management, and adherence to gluten-free labeling standards. Finally, consumer acceptance, driven by perceptions of quality, safety, and sensory attributes, plays a crucial role in market adoption and must be addressed through product optimization, transparent labeling, and effective communication of the nutritional and sustainability benefits of broken rice-based foods.

## CONCLUSIONS AND OUTLOOK

Broken rice, traditionally considered a low-value byproduct, represents a promising resource for sustainable food and ingredient development. Advances in processing, protein recovery, and fermentation-based valorization highlight its potential for producing gluten-free foods, functional ingredients, and plant-based proteins. Future research should emphasize standardization, scalable processing technologies, and life-cycle and economic assessments. Integrating broken rice into circular bioeconomy frameworks will be essential for maximizing its value, reducing waste, and supporting sustainable food systems.

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