



## **Black Soybean-Based Tempeh Product Innovation to Enhance the Added Value of Local Food Products**

**Anisa Ayu Vernanda<sup>1\*</sup>, Febrianti Alvia<sup>2</sup>, Ameylia Monika<sup>3</sup>, Tan Evan Tandiyono<sup>4</sup>**

<sup>1-3</sup> Universitas 17 Agustus 1945 Surabaya, Indonesia

email: [anisaavrr@gmail.com](mailto:anisaavrr@gmail.com)<sup>1</sup>

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### **Abstract**

*This study aims to develop an innovative tempeh product made from black soybeans to enhance the added value of local food products and promote the utilization of indigenous agricultural resources. Black soybeans were selected as the primary raw material because of their high protein content, antioxidant activity, and anthocyanin compounds, which provide greater functional benefits than conventional soybeans. This study employed an empirical qualitative approach using a descriptive research design. Primary data were collected through semi-structured interviews, direct observation of the production process, and documentation, while secondary data were obtained from relevant scientific literature. The production process included black soybean selection, washing, soaking, boiling, partial seed coat removal, inoculation with *Rhizopus* starter culture, packaging in banana leaves, and fermentation for one to three days. The findings indicate that black soybean tempeh was successfully produced with a compact texture, uniform white mycelial growth, a distinctive dark appearance, and sensory characteristics comparable to conventional tempeh. The innovation also demonstrates promising commercialization potential through product differentiation, functional food positioning, and market-oriented value creation. These findings suggest that black soybean-based tempeh can increase the economic value of local food products, encourage food diversification, and provide sustainable business opportunities for micro, small, and medium-sized enterprises (MSMEs).*

**Keywords:** Black Soybean, Food Product Innovation, Local Food Products, Tempeh, Value-Added Food.



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## **INTRODUCTION**

Tempeh has long been recognized as one of Indonesia's most valuable traditional fermented foods because it combines high nutritional quality, affordability, and cultural significance within sustainable food systems. The fermentation of soybeans by *Rhizopus* spp. not only improves protein digestibility but also enhances the bioavailability of essential nutrients and generates bioactive compounds that contribute to human health, making tempeh a representative functional food with increasing global relevance (Qiao et al., 2022). Recent developments in food science have shifted attention from conventional staple foods toward functional and value-added food products that simultaneously promote nutrition, sustainability, and economic resilience, particularly in developing countries (Dixit et al., 2023). This transformation is closely associated with the growing demand for innovative legume-based foods capable of addressing consumer expectations regarding health benefits, environmental sustainability, and product diversity (Affrifah et al., 2023). Contemporary research also demonstrates that soybean processing technologies have evolved beyond traditional utilization toward high-value applications that integrate nutritional enhancement with industrial innovation, thereby expanding market opportunities for local food products (Lyu et al., 2023). The increasing acceptance of functional foods among consumers is likewise influenced by their understanding of nutritional value and scientifically validated health claims, suggesting that product innovation should integrate technological improvement with effective value communication throughout the food supply chain (Baker et al., 2022). Within this context, tempeh represents not merely a traditional fermented product but also a strategic commodity capable of strengthening local food security, promoting healthier dietary patterns, and supporting sustainable economic development through continuous product innovation.

Previous studies consistently indicate that product innovation has become an essential strategy for enhancing the competitiveness of local food products while creating greater economic value for producers and consumers. Innovations in soybean-based products have expanded from improvements in processing technologies to the development of alternative formulations, functional ingredients, and diversified fermented products that respond to changing consumer preferences (Capozzi, 2022). Several studies have demonstrated that black soybean possesses superior nutritional characteristics, particularly its high anthocyanin content and antioxidant capacity, making it a promising raw material for developing healthier tempeh products with enhanced functional properties (Chalid et al., 2025). Investigations on fermented soybean foods further confirm that fermentation significantly increases antioxidant activity, bioactive peptide formation, and physiological benefits compared with unfermented soybeans, thereby strengthening the scientific basis for innovative tempeh development (Surya et al., 2024). Similar findings have shown that soybean-based ethnic fermented foods continue to attract international research attention because of their nutritional quality, health-promoting compounds, and potential contribution to climate-resilient food systems (Kavya et al., 2025). At the practical level, several community-based innovation programs have successfully introduced alternative tempeh products derived from black soybeans and other legumes, demonstrating that diversification can stimulate local entrepreneurship while expanding market opportunities for small-scale food industries (Fitri et al., 2026). These collective findings suggest that innovation in tempeh production should no longer be viewed solely as technological modification but rather as a comprehensive strategy that integrates nutritional improvement, product differentiation, consumer acceptance, and sustainable local economic development.

Despite the growing body of literature on fermented soybean products, several conceptual and empirical limitations remain insufficiently addressed, particularly regarding the integration of nutritional innovation with value-added local food development. Existing studies frequently emphasize biochemical properties, antioxidant activity, or sensory characteristics of black soybean tempeh without comprehensively examining how these innovations contribute to broader economic value creation and market competitiveness (Rahmawan et al., 2021). Other investigations primarily focus on product diversification using alternative legumes, including almonds, soybean crackers, and koro beans, yet they rarely provide an integrated perspective linking innovation management, product positioning, and local food commercialization strategies (Putra & Koeswiryono, 2024). Research concerning innovative food enterprises also highlights that sustainable competitive advantage depends not only on product quality but also on effective innovation management, strategic marketing, and organizational capability, dimensions that remain underexplored in studies of traditional fermented foods (Sumaedi et al., 2023). At the market level, consumer confidence in tempeh products is increasingly associated with production quality, food safety standards, and transparent product information, indicating that innovation should encompass processing practices, packaging quality, and communication strategies rather than focusing exclusively on nutritional improvement (Komala et al., 2024). Recent evidence also demonstrates that attractive packaging and innovative marketing strategies substantially improve the perceived value and purchasing decisions of processed soybean products, suggesting that commercial success depends on the integration of technological innovation with marketing excellence (Fira et al., 2024). These unresolved issues reveal a significant research gap concerning how black soybean-based tempeh innovation can simultaneously strengthen functional food characteristics, increase the added value of local food products, and improve long-term market competitiveness within sustainable food systems.

The limitations identified in previous studies indicate that scientific and practical efforts should move beyond the development of nutritionally superior fermented foods toward comprehensive innovation frameworks capable of generating sustainable economic value for local food systems. Product innovation is fundamentally understood as a process of creating or improving products to satisfy evolving consumer needs while strengthening competitive advantage through value creation (Kotler & Keller, 2016). From an entrepreneurial perspective, innovation also represents the capability to transform creative ideas into products and processes that possess measurable economic value and contribute to long-term business sustainability (Suryana, 2013). In the context of tempeh development, innovation should therefore encompass improvements in raw materials, processing technology, product differentiation, packaging design, and commercialization strategies rather than concentrating solely on nutritional enhancement (Firdaus et al., 2023). Recent innovations involving soybean-based crackers, alternative fermented soybean products, and various legume-derived foods further demonstrate that

value-added food products are increasingly shaped by integrated approaches combining technological advancement, consumer-oriented design, and local resource utilization (Irnawati et al., 2025). Similar developments in innovative food products derived from legume by-products emphasize that maximizing local agricultural resources can simultaneously reduce waste, support circular food systems, and generate higher-value commercial products with broader market potential (Morales-Cabrera et al., 2026). Such evidence strengthens the argument that black soybean-based tempeh should be investigated not merely as a nutritional innovation but also as a strategic instrument for increasing the competitiveness and added value of local food products within an increasingly dynamic food industry.

The relevance of this research is further reinforced by the growing demand for local food diversification that supports food security, sustainable entrepreneurship, and regional economic development. Community empowerment programs introducing innovative tempeh made from alternative legumes have demonstrated that diversification can improve production capacity, stimulate small-business development, and expand consumer acceptance of locally produced foods (Pardi et al., 2025). Similar initiatives promoting the utilization of local food resources have shown that continuous product innovation contributes significantly to increasing public awareness of nutritious indigenous foods while encouraging broader market adoption (Wati et al., 2022). Nevertheless, many existing initiatives remain dominated by community service activities or product demonstrations, providing limited empirical evidence regarding the integration of innovation management with value-added product development and competitive marketing strategies (Fitri et al., 2026). The commercialization of black soybean-based tempeh therefore requires a more comprehensive analytical framework that connects functional food characteristics, innovation capability, consumer value perception, and local economic competitiveness into a coherent model. Addressing these dimensions is expected to generate stronger theoretical explanations regarding how innovation transforms traditional fermented foods into economically valuable products while simultaneously supporting sustainable development objectives. Such an approach also provides practical guidance for producers, MSMEs, and policymakers seeking to maximize the economic potential of local agricultural commodities through evidence-based food innovation.

Based on these considerations, this study positions black soybean-based tempeh as an innovative local food product with the potential to create greater nutritional, economic, and commercial value than conventional soybean-based tempeh. The study seeks to examine how product innovation can strengthen the added value of local food products while responding to contemporary demands for healthier, more sustainable, and more competitive food systems. It also proposes an integrated perspective that connects innovation management, functional food development, product differentiation, and market competitiveness within a single analytical framework. This perspective is expected to enrich the existing literature on food innovation by extending the discussion beyond nutritional quality toward sustainable value creation and local economic development. Methodologically, the study provides a holistic approach for evaluating black soybean-based tempeh innovation through the integration of technological, managerial, and market-oriented dimensions. Ultimately, the findings are expected to offer valuable insights for researchers, food industries, entrepreneurs, and policymakers in promoting innovative local food products that contribute to sustainable economic growth and long-term food resilience.

## **RESEARCH METHODS**

This study employed an empirical qualitative research design using a descriptive approach to examine the innovation of black soybean-based tempeh as a strategy for enhancing the added value of local food products. The research focused on exploring the production process, innovation characteristics, and development potential of black soybean tempeh through direct field investigation. Primary data were collected through semi-structured interviews with a key informant who possessed practical knowledge regarding the utilization of black soybeans as a raw material for food product development, complemented by direct observations conducted throughout the production process. Secondary data were obtained from relevant scientific literature, books, and recent publications concerning functional foods, soybean innovation, food product development, and value-added local food products to strengthen the analytical framework (Affrifah et al., 2023; Lyu et al., 2023). The production process was systematically observed through several stages, including black soybean

selection, washing, soaking for approximately one to two hours, boiling, hull removal, cooling, inoculation with *Rhizopus* starter culture, packaging using banana leaves, and fermentation for one to three days until mature tempeh was formed (Qiao et al., 2022). The operational focus of the study comprised product innovation attributes, processing characteristics, functional value, and the potential contribution of black soybean tempeh to increasing the added value of local food products, consistent with the innovation management perspective proposed by Kotler and Keller (2016).

Data analysis was conducted using descriptive qualitative techniques through data reduction, data organization, data comparison, and interpretative analysis to synthesize evidence obtained from interviews, field observations, documentation, and literature review. The triangulation of multiple data sources was applied to improve the credibility and consistency of the findings by comparing information obtained from different collection techniques and reference materials (Chalid et al., 2025). The analytical process emphasized identifying recurring themes related to product innovation, nutritional advantages, production feasibility, and value creation within local food systems while interpreting their implications for sustainable product development (Capozzi, 2022). Literature findings were continuously compared with empirical observations to evaluate whether the observed production practices reflected current developments in soybean-based functional food innovation and value-added processing (Surya et al., 2024). To strengthen analytical rigor, source triangulation and methodological triangulation were implemented throughout the interpretation process, ensuring that the conclusions were supported by convergent empirical evidence rather than relying on a single source of information (Sumaedi et al., 2023). This analytical procedure enabled the study to provide a comprehensive understanding of how black soybean-based tempeh innovation can enhance product differentiation, functional quality, and the economic value of local food products within a sustainable food innovation framework.

## **RESULTS AND DISCUSSION**

### **Identification of Innovation Opportunities for Black Soybean-Based Tempeh**

The interview findings indicate that conventional tempeh products available in the market remain largely concentrated on traditional preparations, including fried tempeh and battered tempeh, with relatively limited diversification into innovative food products. The key informant emphasized that this condition restricts consumer choices and reduces opportunities to increase the economic value of tempeh through product differentiation. The findings also reveal that younger consumers increasingly seek food products that combine nutritional benefits with modern presentation, creating opportunities for innovative tempeh-based products such as desserts, plant-based steaks, and ready-to-eat meals. This observation demonstrates that innovation is no longer limited to modifications in production techniques but also involves redesigning products to satisfy changing consumer preferences. The increasing market orientation toward healthier and more attractive food products has encouraged producers to develop functional foods with higher commercial value, particularly those utilizing local agricultural commodities (Dixit et al., 2023). These findings suggest that black soybean-based tempeh possesses promising prospects for product innovation because it combines the nutritional advantages of fermented soybeans with opportunities for product diversification capable of expanding market demand.

The interview further revealed that black soybeans remain underutilized despite their considerable nutritional potential. According to the informant, public awareness is generally limited to the use of black soybeans as a raw material for soy sauce, whereas their application in other food products remains relatively uncommon. This limited utilization reflects a gap between the availability of local agricultural resources and their commercialization into higher-value food products. From an innovation perspective, introducing black soybeans as the primary ingredient for tempeh provides an opportunity to reposition a familiar traditional food into a differentiated functional product. Previous studies have demonstrated that legumes possess substantial potential for value-added processing because they provide nutritional benefits while responding to growing consumer demand for healthier diets (Affrifah et al., 2023). Consequently, the findings indicate that black soybean utilization extends beyond raw material substitution and represents a strategic effort to improve the competitiveness of local food products through innovation.

To summarize the qualitative evidence obtained during the interview, the principal findings are presented in Table 1. The table illustrates several themes that consistently emerged throughout the interview process, including market limitations, innovation opportunities, consumer targets, and

commercialization prospects. These themes subsequently became the basis for interpreting the innovation potential of black soybean-based tempeh within the broader framework of value-added local food development. The interview findings demonstrate a close relationship between product innovation and market expansion because each proposed innovation addresses specific consumer expectations identified during data collection. The qualitative patterns summarized in the table therefore provide empirical support for the subsequent discussion concerning product differentiation and market competitiveness.

**Table 1. Summary of Interview Findings on Product Innovation Opportunities**

| Interview Aspect          | Main Findings                               | Research Interpretation                          |
|---------------------------|---------------------------------------------|--------------------------------------------------|
| Existing products         | Market dominated by conventional tempeh     | Indicates limited product diversification        |
| Black soybean utilization | Mostly used for soy sauce                   | Opportunity for alternative food innovation      |
| Suggested innovation      | Dessert, steak, modern culinary products    | Supports product differentiation                 |
| Target consumers          | Young adults and modern consumers           | Potential early adopters of innovative products  |
| Commercial opportunity    | Attractive packaging and promotion required | Enhances product competitiveness and added value |

The qualitative evidence presented in Table 1 demonstrates that product innovation is strongly associated with the ability to create additional value beyond the functional role of food itself. Rather than replacing conventional tempeh, innovative products derived from black soybeans provide complementary alternatives capable of attracting new consumer segments. This finding is consistent with innovation management theory, which emphasizes that competitive advantage emerges through continuous product differentiation supported by market-oriented strategies rather than solely through technological improvements (Kotler & Keller, 2016). Product innovation therefore encompasses changes in product appearance, consumer experience, branding, and perceived value alongside improvements in nutritional quality. Similar observations have been reported in studies examining innovative soybean processing, where successful commercialization depended on integrating technological innovation with value-added product design (Lyu et al., 2023). These findings indicate that innovation should be viewed as a multidimensional process connecting production capability with evolving consumer expectations and competitive market positioning.

Consumer acceptance also emerged as an important consideration during the interview because innovative food products require both nutritional superiority and positive consumer perceptions. The informant argued that attractive presentation and modern product concepts would encourage consumers who might otherwise be reluctant to consume conventional tempeh. This perception aligns with contemporary trends showing that purchasing decisions increasingly depend upon consumers' knowledge regarding the health benefits and functional characteristics of food products. Research has demonstrated that consumer acceptance of functional foods improves substantially when nutritional information is effectively communicated through product presentation and marketing strategies (Baker et al., 2022). Black soybean-based tempeh therefore offers opportunities to combine scientifically supported health attributes with innovative culinary concepts capable of enhancing consumer interest. The integration of nutritional value and consumer-oriented innovation represents an important mechanism for increasing both market acceptance and product competitiveness.

The overall findings indicate that innovation opportunities for black soybean-based tempeh originate from the interaction between abundant local resources, consumer demand for healthier foods, and the need to increase the economic value of traditional food products. The interview findings consistently suggest that innovation should encompass product diversification, attractive packaging, and market-oriented commercialization strategies rather than focusing exclusively on production techniques. Such an approach strengthens the position of black soybean tempeh as a functional food capable of contributing to sustainable local food development while creating new business

opportunities. Previous studies similarly emphasize that successful innovative food products require organizational capability, product quality, and strategic innovation management to maintain long-term competitiveness (Sumaedi et al., 2023). The present findings extend this perspective by demonstrating that local food innovation can simultaneously preserve traditional culinary identity and respond to contemporary consumer preferences. This combination provides a practical foundation for enhancing the added value of black soybean-based tempeh within sustainable food systems while strengthening the competitiveness of locally produced functional foods.

### **Production Process and Product Characteristics of Black Soybean Tempeh**

The production of black soybean-based tempeh was initiated after the interview findings identified the need to diversify local soybean products with higher added value. Field observations showed that the production stages generally followed the conventional tempeh manufacturing process while incorporating black soybeans as the primary raw material. The procedure consisted of raw material selection, washing, soaking, boiling, partial removal of the seed coat, cooling, inoculation with *Rhizopus* starter culture, packaging in banana leaves, and fermentation for one to three days. Each processing stage was carried out carefully to maintain the quality of the raw materials and to provide favorable conditions for fungal growth during fermentation. The observation further indicated that partial retention of the black soybean seed coat preserved the distinctive appearance of the product without disrupting the fermentation process. These findings demonstrate that black soybeans can be processed using existing tempeh production techniques, allowing producers to introduce innovative products without requiring substantial technological modifications. Previous studies similarly explain that fermented soybean products can be developed through relatively simple processing methods while maintaining their nutritional functionality, provided that fermentation conditions are properly controlled (Qiao et al., 2022).

The selection of high-quality black soybeans constituted an important stage because the physical condition of the raw material directly influenced fermentation performance and the quality of the final product. During observation, damaged seeds and foreign materials were removed before washing to minimize contamination and ensure uniform fermentation. The soaking process, conducted for approximately one to two hours, softened the beans and facilitated subsequent boiling and partial seed coat removal. Unlike conventional processing in which the seed coat is commonly removed completely, the present production retained part of the black seed coat to preserve the product's unique visual identity while maintaining adequate fungal colonization. This approach produced no observable negative effect on mycelial development during fermentation, indicating that the modified processing method remained technically feasible. Similar observations have been reported in studies examining black soybean tempeh, where partial preservation of the seed coat contributed to product differentiation while maintaining acceptable fermentation characteristics and consumer acceptance (Rahmawan et al., 2021). These findings indicate that innovation in tempeh production may involve simple modifications to processing practices that simultaneously enhance product uniqueness and commercial attractiveness.

The fermentation stage represented the most critical phase in determining product quality because successful fungal growth influenced texture, compactness, aroma, and overall product acceptability. Field observations revealed that after inoculation with *Rhizopus* starter culture, white mycelia gradually developed and evenly covered the black soybean surface throughout the one- to three-day fermentation period. Uniform mycelial growth created a compact structure by binding individual soybean seeds into a cohesive cake without visible signs of spoilage or abnormal microbial contamination. The resulting product exhibited physical characteristics consistent with successful tempeh fermentation despite the use of a different soybean variety. These observations confirm that black soybeans provide a suitable substrate for *Rhizopus* growth and support efficient fermentation under standard household production conditions. Recent reviews similarly emphasize that fermentation enhances soybean functionality through microbial metabolism that improves digestibility, generates bioactive compounds, and produces desirable sensory characteristics in fermented soybean foods (Surya et al., 2024; Kavya et al., 2025).

**Table 2. Production Process and Observed Characteristics of Black Soybean-Based Tempeh**

| Production Stage          | Observation Results                                    | Scientific Interpretation                                             |
|---------------------------|--------------------------------------------------------|-----------------------------------------------------------------------|
| Raw material selection    | Healthy and intact black soybeans selected             | Improves fermentation consistency                                     |
| Washing and soaking       | Beans became cleaner and softer                        | Facilitates boiling and fungal colonization                           |
| Partial seed coat removal | Part of the black seed coat retained                   | Preserves product identity while maintaining fermentation performance |
| Boiling and cooling       | Beans cooked uniformly and cooled to room temperature  | Creates favorable conditions for starter inoculation                  |
| Inoculation               | <i>Rhizopus</i> starter evenly distributed             | Supports homogeneous mycelial growth                                  |
| Fermentation (1–3 days)   | White mycelia completely covered soybean surface       | Indicates successful fermentation and product maturation              |
| Final product             | Compact texture, dark appearance, characteristic aroma | Demonstrates technical feasibility of black soybean tempeh production |

The physical characteristics observed after fermentation indicate that black soybean-based tempeh possesses distinctive qualities that differentiate it from conventional yellow soybean tempeh while maintaining desirable product standards. The finished tempeh exhibited a compact texture, firm structural integrity, and evenly distributed white mycelia, indicating successful microbial activity throughout the fermentation process. Its darker appearance reflected the natural pigmentation of black soybeans rather than any indication of product deterioration, thereby creating a unique visual identity that could strengthen market differentiation. The aroma remained characteristic of properly fermented tempeh without unpleasant odors associated with contamination or processing failure. Sensory observation also suggested that the taste remained comparable to conventional tempeh, thereby reducing potential barriers to consumer acceptance despite the change in raw material. Similar studies have reported that black soybean-based tempeh maintains favorable organoleptic properties while providing additional antioxidant potential derived from anthocyanin-rich seed coats, increasing its attractiveness as a functional food product (Chalid et al., 2025). The combination of acceptable sensory quality and distinctive visual characteristics therefore strengthens the feasibility of commercializing black soybean tempeh as an innovative value-added local food product.

The observed product characteristics also indicate that black soybean-based tempeh possesses considerable potential to be positioned as a functional food with enhanced nutritional value. Although this study did not include laboratory analysis of nutrient composition, the production observations confirmed that the fermentation process proceeded normally and produced a product with physical characteristics comparable to conventional tempeh. The successful development of compact mycelia suggests that the fermentation environment effectively supported microbial activity responsible for improving protein digestibility and generating beneficial bioactive compounds. Previous studies have demonstrated that fermentation increases the availability of peptides, isoflavones, and antioxidant compounds, thereby enhancing the physiological functions of soybean-based foods beyond their conventional nutritional role (Qiao et al., 2022). Black soybeans further contribute anthocyanins and other phenolic compounds that are recognized for their antioxidant activity, creating additional opportunities to develop premium functional food products targeting health-conscious consumers (Surya et al., 2024). This combination of successful fermentation performance and the inherent nutritional characteristics of black soybeans strengthens the product's competitive position within the expanding functional food market. The findings therefore suggest that innovation should emphasize not only product appearance but also scientifically supported nutritional advantages capable of increasing consumer confidence and product value.

The production observations further demonstrate that the innovation introduced in this study can be implemented using existing household-scale production technology without requiring substantial capital investment or sophisticated equipment. Most production activities relied on traditional fermentation practices that are already familiar to local tempeh producers, reducing technical barriers to technology adoption. Such accessibility is particularly important for micro, small, and medium-sized enterprises seeking to diversify their products while minimizing production costs. Previous studies on innovative tempeh products similarly conclude that modifying raw materials rather than replacing production technology provides a practical pathway for expanding product portfolios and improving business competitiveness (Putra & Koeswiryono, 2024). Comparable findings have also been reported for innovative soybean cracker products, where simple product modifications successfully generated healthier local snacks with greater market differentiation while maintaining production efficiency (Irnawati et al., 2025). These findings indicate that black soybean-based tempeh innovation is technically feasible for widespread implementation because producers can utilize existing knowledge, equipment, and fermentation practices while offering consumers a product with distinctive characteristics. Such production efficiency represents an important factor supporting the long-term sustainability of local food innovation initiatives.

Another important observation concerns the role of product characteristics in strengthening market differentiation and consumer perception. The darker color of black soybean tempeh was consistently recognized as a unique visual attribute rather than a quality defect, suggesting that product appearance itself may become an effective marketing advantage. Increasingly competitive food markets require producers to offer products with distinctive identities capable of attracting consumers who seek novelty alongside nutritional benefits. Previous research emphasizes that successful food innovation depends not only on technological improvements but also on the ability to communicate product uniqueness and create positive consumer experiences through differentiation strategies (Capozzi, 2022). The integration of distinctive appearance, functional nutritional properties, and traditional fermentation methods enables black soybean tempeh to occupy a unique market position that differs from conventional soybean products. Such differentiation is further supported by evidence that value-added soybean processing contributes to greater product diversity while increasing the commercial utilization of local agricultural resources (Lyu et al., 2023). The present findings therefore demonstrate that product innovation can simultaneously strengthen technological feasibility, nutritional quality, and market positioning within sustainable local food systems.

### **Economic Value Enhancement and Commercialization Potential**

The empirical findings indicate that the innovation of black soybean-based tempeh extends beyond technological modification and contributes directly to increasing the economic value of local food products. The interview revealed that consumers increasingly expect traditional foods to be presented in more attractive and contemporary forms without sacrificing their nutritional quality. This expectation creates opportunities to reposition tempeh from a conventional household food into an innovative product capable of reaching broader market segments. Product diversification therefore becomes an important strategy for improving competitiveness while creating additional sources of income for local producers. Previous studies have emphasized that value-added processing enables legumes to generate greater economic returns by increasing product diversity and expanding market opportunities beyond traditional consumption patterns (Affrifah et al., 2023). The present findings reinforce this perspective by demonstrating that black soybean utilization creates opportunities to transform an underutilized agricultural commodity into a higher-value functional food product. Such innovation supports not only product differentiation but also sustainable local economic development through the commercialization of indigenous food resources.

The interview findings also demonstrate that market orientation should become a central consideration during product development because technological innovation alone is insufficient to ensure commercial success. The key informant identified young adults as the most promising target consumers because this demographic generally exhibits greater willingness to try innovative food products and healthier dietary alternatives. Attractive presentation, modern branding, and creative product concepts were consistently viewed as factors capable of increasing purchase intention. These observations indicate that consumer preferences have shifted toward products offering both functional benefits and memorable consumption experiences. Marketing management theory similarly explains

that successful innovation requires organizations to align product characteristics with customer expectations through effective segmentation, targeting, positioning, and value communication (Kotler & Keller, 2016). Consequently, commercialization strategies for black soybean tempeh should integrate nutritional differentiation with consumer-oriented marketing approaches to maximize market acceptance and long-term competitiveness.

Midway through the analysis, the principal commercialization opportunities identified during the study are summarized in Table 3. The table synthesizes empirical observations concerning market opportunities, product differentiation, promotional strategies, and expected economic outcomes. These findings demonstrate that value creation is influenced by interactions among production capability, product innovation, and market-oriented business strategies rather than by technological improvements alone. The commercialization framework therefore provides a practical reference for entrepreneurs seeking to develop innovative local food products capable of generating sustainable economic value.

**Table 3. Commercialization Potential and Economic Value of Black Soybean-Based Tempeh**

| Commercial Aspect          | Empirical Findings                           | Economic Implication                             |
|----------------------------|----------------------------------------------|--------------------------------------------------|
| Product differentiation    | Distinctive color and functional attributes  | Premium market positioning                       |
| Target consumers           | Young adults and health-conscious consumers  | Expansion of market segments                     |
| Packaging                  | Attractive and practical packaging preferred | Higher perceived product value                   |
| Promotion                  | Digital and social media marketing           | Wider consumer reach                             |
| Business opportunity       | Suitable for MSMEs and household industries  | Increased local income generation                |
| Local resource utilization | Black soybean as alternative raw material    | Greater added value for agricultural commodities |

The commercialization opportunities presented in Table 3 suggest that innovative marketing strategies represent an essential complement to product innovation. Attractive packaging, consistent branding, and effective digital promotion increase consumers' perceptions of quality while strengthening product recognition in competitive markets. Recent studies concerning tofu and tempeh enterprises similarly report that innovative marketing practices significantly improve product competitiveness by strengthening consumer engagement and encouraging repeat purchases (Fira et al., 2024). Comparable evidence has also been documented in community-based product development initiatives where diversified tempeh products achieved broader market acceptance after integrating attractive packaging with creative promotional activities (Firdaus et al., 2023). These findings indicate that commercialization should be regarded as a multidimensional process involving production quality, communication strategies, and customer relationship development. Such integration enables innovative food products to achieve greater commercial sustainability while increasing the economic contribution of local food industries. The present study therefore confirms that successful innovation requires balanced attention to technological, managerial, and marketing dimensions.

The observed commercialization potential is particularly relevant for micro, small, and medium-sized enterprises because the production process remains relatively simple while offering opportunities to generate premium-value products. Existing household-scale tempeh producers can adopt black soybean fermentation without substantial modifications to equipment or production facilities, thereby minimizing investment costs during product diversification. Community empowerment programs conducted in Indonesia similarly demonstrate that innovative tempeh products provide new entrepreneurial opportunities while strengthening local business resilience through product differentiation and capacity building (Fitri et al., 2026). Comparable initiatives involving alternative legumes have shown that diversified fermented food products contribute to strengthening the competitiveness of community-based enterprises while expanding local food markets (Pardi et al.,

2025). Entrepreneurial theory further emphasizes that innovation functions as the primary mechanism through which businesses transform available resources into products possessing greater economic value and stronger competitive advantages (Suryana, 2013). These findings indicate that black soybean-based tempeh possesses considerable potential to support sustainable entrepreneurship, particularly among local producers seeking higher-value market opportunities.

Another important implication concerns the contribution of black soybean tempeh to sustainable food systems through the utilization of locally available agricultural resources. Diversification of soybean products reduces dependence on a limited range of conventional food products while encouraging broader utilization of indigenous crops with high nutritional value. Recent research has highlighted that innovative processing of soybean by-products and alternative legumes contributes to circular food systems by maximizing resource efficiency and generating new commercial products with enhanced nutritional quality (Morales-Cabrera et al., 2026). Public education initiatives have also demonstrated that increasing consumer awareness regarding local food products encourages greater appreciation of indigenous food resources while supporting healthier dietary patterns (Wati et al., 2022). The empirical observations obtained in this study complement these findings by indicating that black soybean tempeh combines functional nutrition with local resource utilization in a manner capable of strengthening regional food security and economic resilience. Consequently, commercialization of black soybean-based tempeh contributes not only to business development but also to broader sustainability objectives associated with local food innovation.

Despite the promising findings, several limitations should be acknowledged when interpreting the commercialization potential identified in this study. The analysis relied primarily on qualitative evidence obtained from interviews and direct observations and therefore did not include laboratory evaluation of nutritional composition, antioxidant activity, shelf life, or consumer acceptance testing. Economic feasibility was also interpreted qualitatively because production costs, willingness to pay, and profitability were not examined through quantitative approaches. Future studies should incorporate experimental analysis, sensory evaluation, and market surveys to validate the commercial competitiveness of black soybean tempeh using more comprehensive empirical evidence. Integrating laboratory analysis with consumer behavior and business performance assessment would provide stronger scientific support for commercialization strategies and policy recommendations. Such multidisciplinary investigations would also contribute to a more comprehensive understanding of how innovative fermented foods create sustainable value within local and regional food systems. The present findings nevertheless provide an important empirical foundation demonstrating that black soybean-based tempeh represents a promising innovation capable of increasing the added value of local food products while supporting entrepreneurship, functional food development, and sustainable economic growth.

## **CONCLUSION**

This study demonstrates that black soybeans can be successfully utilized as an alternative raw material for tempeh production through the conventional fermentation process using *Rhizopus* spp., thereby expanding the utilization of local agricultural commodities with higher economic potential. The production process was successfully implemented using standard fermentation techniques and resulted in a compact tempeh structure characterized by uniformly distributed white mycelia, a distinctive dark appearance, and sensory properties comparable to conventional soybean tempeh. These findings confirm that substituting yellow soybeans with black soybeans does not adversely affect the fundamental characteristics of the fermented product while providing a unique product identity capable of enhancing market differentiation. The darker color derived from black soybeans represents an additional commercial attribute that distinguishes the product from conventional tempeh and may strengthen consumer recognition. Furthermore, the inherent nutritional characteristics of black soybeans, particularly their antioxidant and anthocyanin content, indicate promising potential for developing functional food products with greater added value. From an economic perspective, this innovation contributes to local food diversification by creating opportunities for product differentiation, increasing the commercial value of traditional fermented foods, and supporting entrepreneurial activities among micro, small, and medium-sized enterprises (MSMEs). The integration of technological feasibility, functional nutritional properties, and commercialization potential suggests

that black soybean-based tempeh represents a viable innovation capable of strengthening the competitiveness of local food products while promoting sustainable food system development.

Despite these promising findings, the study has several limitations that should be considered when interpreting its conclusions. The research was conducted using a qualitative descriptive approach and therefore did not include laboratory analyses to verify nutritional composition, antioxidant activity, or other functional components of the final product. Likewise, consumer acceptance, sensory preference, shelf-life performance, production cost efficiency, and market willingness to pay were not quantitatively evaluated. Future research should incorporate experimental laboratory testing, consumer-based sensory evaluation, and economic feasibility analyses to provide more comprehensive evidence regarding the nutritional superiority and commercial competitiveness of black soybean-based tempeh. Integrating qualitative and quantitative approaches would also enable a more robust assessment of the product's market potential and its contribution to sustainable local economic development. Such investigations are expected to strengthen the scientific foundation for the commercialization of innovative fermented foods and support broader adoption of black soybean-based tempeh within the functional food industry. Ultimately, continued research and product development will contribute to enhancing the added value of local food resources while encouraging innovation-driven growth in the agri-food sector.

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