

A Review: Production of Analog Rice from Mocaf and Soybean-Based Flours for Food Diversification

A'am Sahal Mushoffi¹, Heny Kusumayanti²

^{1,2}Department of Industrial Chemical Engineering Technology, Vocational School, Universitas Diponegoro, Semarang City, Central Java, 50275, Indonesia.

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ABSTRACT

Rice is the main staple food for most populations, leading to high consumption rates and dependency on a single food source. Developing analog rice from local and sustainable ingredients is an effective approach to promote food diversification and reduce reliance on conventional rice. This review examines the production of analog rice using Modified Cassava Flour (Mocaf) and soybean flour as complementary materials. Mocaf provides carbohydrates and a suitable starch matrix, while soybean flour enhances protein, fiber, and nutrient content. The extrusion process is commonly applied due to its efficiency in blending, gelatinization, and shaping. Previous studies indicate that analog rice made from mocaf–soybean blends has higher protein content (8–12%), balanced moisture levels, and a lower glycemic index compared to white rice. These characteristics highlight the potential of mocaf–soybean analog rice as a functional and nutritious food that supports food diversification and contributes to nutritional improvement.

Keywords: Analog rice, Mocaf, Soybean flour, Extrusion, Food diversification, Functional food

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INTRODUCTION

In Indonesia and much of Asia, rice dominates the staple diet, but this heavy reliance has raised significant health and food security concerns. Nadhifa et al. (2025) note that milled white rice is rich in carbohydrates but lacks protein, dietary fiber, and micronutrients, making populations dependent on it vulnerable to malnutrition and chronic diseases. Indonesian per capita rice consumption remains extremely high exceeding 110 kg per year and recent trends have shown increasing incidences of diabetes and cardiovascular diseases associated with rice's high glycemic index (Harlina et al., 2023). Budijanto and Yuliana (2015) similarly argue that Indonesia's endemic rice dependence undermines both food security and economic resilience, given its heavy reliance on imported rice. These nutritional limitations and supply vulnerabilities emphasize the urgent need to broaden staple consumption beyond conventional paddy rice.

Food diversification has long been a national strategy to address these challenges by promoting the use of various local carbohydrate sources. The Indonesian government initiated an official diversification program as early as 1974, yet rice remains dominant in household consumption patterns. The slow progress of this initiative is largely attributed to cultural preferences, limited consumer awareness, and a lack of appealing substitutes that mimic the sensory and cooking characteristics of rice (Nurlaela et al., 2023). Nevertheless, research consistently shows that expanding dietary variety through locally sourced staples can improve public health outcomes. Local tubers and legumes generally exhibit lower glycemic indices and higher fiber or protein content than polished rice, thus helping to reduce risks of obesity, diabetes, and protein-energy

malnutrition (Wahyuni et al., 2024). In practice, diversification efforts have increasingly focused on cassava, corn, sweet potato, and other starch-rich crops. Among these innovations, analog rice—rice-like granules produced from local flour sources—has emerged as a promising “vehicle” for diversification, as it allows consumers to maintain traditional cooking and eating habits while introducing more nutritious alternatives (Putri et al., 2024).

Cassava and soybean play particularly complementary roles in analog rice formulations. Cassava, especially in its modified fermented form known as Modified Cassava Flour (Mocaf), serves as the main carbohydrate base due to its high amylopectin starch content and wide availability in Indonesia (Nadhifa et al., 2025). However, cassava flour alone provides limited protein content; therefore, analog rice formulations are often fortified with high-protein ingredients such as soybean flour. Soybeans contain approximately 35–40% protein and appreciable dietary fiber significantly higher than white rice’s 6% making them an excellent fortifier. Several studies confirm that incorporating soy into cassava-based analog rice substantially increases protein content while lowering the overall glycemic index. For example, Mahendradatta et al. (2024) reported that analog rice made with legume flours, including soybean, achieved the highest protein concentration and a low GI (~40). Similarly, Bahlawan et al. (2023) optimized a mocaf–soy formulation (50:50) containing approximately 17% protein and 7% fiber, demonstrating its suitability as a nutritionally enhanced staple. In summary, Mocaf contributes the starch matrix, while soybean enhances protein and micronutrient composition, yielding analog rice with a more balanced nutritional profile compared to conventional rice.

Production of analog rice generally employs extrusion technology to form rice-like grains. Extrusion applies controlled heat, pressure, and shear to a starch–protein mixture, gelatinizing carbohydrates and shaping the material through a die. In analog rice production, an oval die is typically used to mimic the physical appearance of natural rice grains (Nadhifa et al., 2025). Compared to simple granulation methods, extrusion yields more uniform and stable products with better texture and sensory quality. Key parameters such as temperature, screw speed, and moisture level can be fine-tuned to optimize cooking quality and water absorption while minimizing nutrient degradation (Meilany et al., 2024). Hence, extrusion serves as a critical process that enables Mocaf–soy blends to be transformed into acceptable rice-like products that align with Indonesian culinary norms.

Overall, analog rice represents a promising innovation to support food diversification and nutrition improvement in rice-dependent societies. Budijanto and Yuliana (2015) emphasize the need for integrated research encompassing raw material selection, formulation, and process optimization to realize analog rice’s potential as a functional staple. Therefore, this review focuses on the production of analog rice made from locally important ingredients—Modified Cassava Flour (Mocaf) and soybean flour—examining their functional synergy, extrusion processes, and reported nutritional and sensory characteristics. This discussion aims to inform scholars, practitioners, and policymakers about the role of Mocaf–soybean analog rice in achieving sustainable food diversification and national food security in Indonesia.

RESEARCH METHODS

This review was conducted using the Systematic Literature Review (SLR) method to collect, evaluate, and synthesize relevant studies on the production of analog rice from Modified Cassava

Flour (Mocaf) and soybean flour. Literature searches were performed through Google Scholar, ScienceDirect, and the SINTA database using the keywords “Analog Rice”, “Mocaf Flour”, “Soybean Flour”, “Extrusion Technology”, and “Food Diversification”. The search was limited to peer-reviewed national and international journals published between 2013 and 2025. Articles were selected based on their relevance to the topic, full-text availability, and focus on the formulation, processing, or nutritional characteristics of Mocaf–soybean analog rice. Approximately 100 studies were identified, and after applying inclusion and exclusion criteria, 25 key articles were reviewed in detail. This systematic approach ensured that the collected data were comprehensive, credible, and aligned with the purpose of analyzing the potential of Mocaf–soybean analog rice for food diversification.

DISCUSSION OF RESULTS

Potential of Analog Rice for Food Diversification

Indonesia’s heavy dependence on white rice has created nutritional and food security challenges. Polished rice contains mainly carbohydrates but limited protein and micronutrients, leading to malnutrition and higher risks of chronic diseases (Nadhifa et al., 2025). Budijanto and Yuliana (2015) note that such dependency also threatens national food resilience due to import reliance. Although the government initiated a food diversification program in 1974, it progressed slowly because of strong cultural preferences for rice (Budijanto & Yuliana, 2015).

Experts argue that encouraging the use of local carbohydrate sources—such as cassava, corn, and legumes—could reduce this dependency (Harlina et al., 2023). Analog rice, made from local crops but shaped and cooked like regular rice, offers a culturally acceptable substitute (Rozi et al., 2022). Recent findings confirm that analog rice from cassava or banana flour has been successfully adopted in community-scale production, improving household food security (Lalong et al., 2025).

Formulations combining Modified Cassava Flour (Mocaf) and soybean flour have shown high nutritional potential. Mahendradatta et al. (2024) observed that adding soy significantly increases protein while maintaining a low glycemic index (~40). Similarly, Bahlawan et al. (2023) reported a mocaf–soy blend (50:50) with ~17% protein and 7% fiber substantially higher than white rice. A study by Handajani et al. (2020) also found cassava–soy analog rice with ~9 g protein per 100 g. These findings are supported by recent research by Azhari (2025), who noted that composite analog rice made from porang and gembili tubers also displayed favorable proximate and physical characteristics, though sensory attributes remained a challenge. In addition, Anggraeni (2025) demonstrated that incorporating antioxidant-rich ingredients such as Moringa and purple sweet potato enhances functional value and color stability, suggesting that similar fortification strategies could also benefit Mocaf–soy formulations. Together, these findings underscore that Mocaf–soy analog rice offers strong potential as a nutrient-dense and functional staple that aligns with Indonesia’s food diversification goals.

Ingredients Used for Analog Rice

Analog rice is formulated to replicate the nutritional and functional characteristics of natural rice grains. Its nutritional value depends largely on the composition and quality of the ingredients used. Suitable raw materials should provide adequate carbohydrates, protein, fiber, and essential micronutrients comparable to natural rice (Sadek et al., 2016). To achieve this, proper selection of local ingredients especially those rich in starch and protein is essential.

The production of analog rice requires the right ratio of carbohydrate and protein sources so that compact, rice-like granules can form (Andarwulan, 2011). In mocaf–soy formulations, Modified Cassava Flour (Mocaf) serves as the main carbohydrate base, while soybean flour acts as a protein fortifier. Additional ingredients such as water, binding agents, and emulsifiers help achieve the desired texture and uniformity of the grains (Herawati et al., 2013). Below are the key components typically used in mocaf–soy analog rice production:

1. Modified Cassava Flour (Mocaf)

Mocaf serves as the primary carbohydrate source and forms the structural base of analog rice. Its high amylopectin starch content supports gelatinization and cohesive granule formation during extrusion (Nadhifa et al., 2025). Fermentation during Mocaf processing enhances physicochemical qualities such as solubility, swelling power, and water absorption capacity (Rozi et al., 2022). Recent studies show that combining Mocaf with other local flours such as corn or porang further improves texture and sensory properties (Florie & Kusumayanti, 2024). Given its local availability and low cost, Mocaf remains a sustainable key material for national food diversification efforts (Faradilla et al., 2025).

2. Soybean Flour

Soybean flour provides 35–40% protein, 7–9% fiber, and essential fatty acids, making it an excellent supplement to mocaf (Bahlawan et al., 2023). Its inclusion improves the amino acid profile, digestibility, and overall protein content of analog rice (Mahendradatta et al., 2024). In addition, studies have shown that soy fortification significantly lowers the glycemic index (GI) and enhances the functional quality of analog rice (Novikasari et al., 2023). Furthermore, soybean-based analog rice demonstrates better water absorption and a softer texture after cooking, which contributes to higher consumer acceptability (Meilany et al., 2024).

3. Water

Water functions as a plasticizer that reduces dough viscosity and allows proper shaping during extrusion (Ding et al., 2005). Adequate moisture levels, typically between 25–35%, also help achieve uniform gelatinization and prevent the formation of cracks or air bubbles in the grains, ensuring consistent texture and structural integrity of the analog rice (Nadhifa et al., 2025).

4. Palm Oil

Palm oil contains tocopherols and tocotrienols, which act as natural antioxidants and serve as a source of carotenoids. In analog rice production, palm oil functions primarily as a binder, helping to improve the texture and cohesiveness of the rice granules (Septyaningsih et al., 2016).

5. Glycerol Monostearate (GMS)

Glycerol monostearate (GMS) is a type of nonionic surfactant widely used in the pharmaceutical and food industries. In the production of analog rice, GMS functions as a lubricant within the extrusion barrel, helping to prevent the extrudate from sticking or clumping during the extrusion process (Damat et al., 2020).

Analog Rice Production Process

The production of analog rice made from Modified Cassava Flour (Mocaf) and soybean flour aims to develop a nutrient-rich, rice-like product containing balanced levels of carbohydrates and proteins. The formulation of this analog rice can be improved by adding supplementary ingredients such as starch binders and emulsifiers (e.g., glycerol monostearate or GMS) to obtain optimal nutritional and physical properties (Mahendradatta et al., 2024).

The selection of raw materials, additives, and processing techniques—as well as the ratio between moaf and soybean flour—greatly affects the quality, uniformity, and texture of the final analog rice grains. Therefore, these factors must be carefully controlled during production to ensure consistent results (Andarwulan, 2011). In general, the manufacturing process of moaf–soy analog rice consists of several major stages, namely formulation, preconditioning, extrusion, drying, and product (Faleh et al., 2013).

1. Formulation

The formulation stage aims to produce an appropriate blend of ingredients based on predetermined variables. During this process, Modified Cassava Flour (Moaf) and soybean flour are used in powdered form to ensure even mixing and consistent nutrient distribution. Additional materials such as glycerol monostearate (GMS), palm oil, and water are incorporated in specific proportions to enhance cohesion, lubrication, and emulsification during production. Before entering the extrusion stage, the mixture must reach uniform moisture and texture to ensure smooth and stable processing (Faleh et al., 2013).

2. Preconditioning

The preconditioning phase functions to achieve uniform hydration of the flour particles, allowing the dough to become pliable and flow consistently during extrusion. Controlled addition of water and mild heating at this stage promote partial gelatinization, which improves dough plasticity and processability. This preparation ensures that the mixture can be extruded efficiently while maintaining even texture and shape (Faizatun et al., 2020).

3. Extrusion

During the extrusion stage, the preconditioned dough is subjected to higher temperatures than in the preconditioning phase. Inside the extruder, the mixture experiences intense heat, pressure, and shear, which induce starch gelatinization and transform the mass into a continuous plastic-like dough. The material is then forced through a die to form rice-shaped granules with uniform size and texture, determining the structural and physical characteristics of the analog rice (Faizatun et al., 2020).

4. Drying

Following extrusion, the analog rice still contains high moisture levels, necessitating a drying process using either sunlight or a mechanical dryer. This step lowers the water content to a stable level, preventing microbial growth and extending product shelf life. Controlled drying also improves the hardness, durability, and rehydration quality of the grains during cooking and storage (Mishra et al., 2012).

5. Product

The dried analog rice is then packed in airtight containers to prevent moisture absorption and inhibit the growth of mold and bacteria. Proper packaging ensures product hygiene, maintains quality during storage, and extends the shelf life of the analog rice (Mahendradatta et al., 2024).

CONCLUSION

The production of analog rice using Modified Cassava Flour (Mocaf) and soybean flour results in a product with high carbohydrate and protein content, offering a nutritional profile comparable to that of white rice. The combination of Mocaf as a carbohydrate source and soybean as a protein fortifier produces analog rice that is rich in fiber, has a lower glycemic index, and provides better nutritional balance. This Mocaf–soybean-based analog rice shows great potential to

be developed as an alternative staple food to reduce dependency on conventional rice. Furthermore, its use of locally available ingredients supports food diversification efforts and contributes to sustainable food security in Indonesia.

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