Vol. 15, No. 2 (2026): 597 - 607 https://dx.doi.org/10.23960/jtepl.v15i2.597-607

JURNAL TEKNIK PERTANIAN LAMPUNG

ISSN 2302-559X (print) / 2549-0818 (online)
Journal homepage : https://jurnal.fp.unila.ac.id/index.php/JTP

Evaluation of the Physical and Chemical Profiles of Instant Rice Based on Germinated Brown Rice of Inpari 32 Variety

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Article History:

Received : 5 December 2025
Revised : 4 March 2026
Accepted : 1 April 2026

Keywords:

Germinated brown rice,
Germination,
Inpari-32,
Instant rice,
Soaking.

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ABSTRACT

Brown rice is dehulled rice that retains its bran layer and therefore has higher fiber and nutrient content than white rice. Germination and instant processing are applied to improve the quality of brown rice and shorten cooking time. This study aimed to evaluate the effects of soaking duration (12 and 24 h) and germination time (36, 48, and 60 h) on the physical and chemical properties of instant rice produced from germinated brown rice (GBR) of the Inpari-32 variety, using a nested randomized block design. Variables for GBR included yield, radicle emergence, moisture content, ash content, and amylose content, while instant rice was evaluated for bulk density, yield, moisture content, ash content, and amylose content. Data was analyzed using ANOVA followed by DMRT at the 5% significance level. Results showed that soaking and germination duration had no significant effect on GBR yield or amylose content of instant rice, whereas germination time significantly affected GBR moisture and ash content, which ranged within national quality limits. The resulting instant rice had low bulk density, acceptable moisture content, and relatively high ash (mineral) content. A combination of 12 h soaking and 36 h germination is recommended as an efficient treatment to produce instant rice from GBR with acceptable physical and chemical quality.

1. INTRODUCTION

Rice remains the primary staple food of the Indonesian population and contributes substantially to daily energy intake. Subang Regency is recognized as one of the major rice-producing areas in West Java, where high-yielding varieties such as Inpari 32 are extensively cultivated by farmers (BPS, 2023). Despite this, rice consumption in Indonesia is still predominantly focused on white rice. Conventional rice milling removes the bran and germ layers, which are rich sources of dietary fiber, vitamins, minerals, and various bioactive compounds. In contrast, brown rice undergoes only husk removal and therefore retains the aleurone layer and germ. As a result, brown rice contains higher levels of dietary fiber, vitamins, minerals, lignans, and bioactive compounds, including gamma-aminobutyric acid (GABA) and other antioxidants, compared to white rice (Kim *et al*., 2020; Munarko *et al*., 2020; Ren *et al*., 2022; Sibian *et al*., 2017; Summpunn *et al*., 2023; Ukpong *et al*., 2021). This nutritional profile positions brown rice as a potential functional food that supports digestive health, glycemic index regulation, and the prevention of various degenerative diseases (Ma *et al*., 2023; Ukpong *et al*., 2023).

Despite these advantages, consumer acceptance of brown rice remains relatively low. Brown rice generally requires longer cooking times, exhibits a firmer texture, and has sensory attributes that are perceived as less familiar compared to the soft and fluffy texture of white rice (Munarko *et al*., 2020; Sibian *et al*., 2017). These sensory characteristics represent a major barrier to the wider adoption of brown rice, particularly among consumers with fast-paced lifestyles. Therefore, postharvest processing innovations are required to preserve the nutritional superiority of brown rice while simultaneously improving its texture and convenience of preparation.

One of the most widely studied approaches to improve the quality of brown rice is germination or sprouting. Germination activates the embryo and endogenous enzymes following the imbibition stage, thereby triggering metabolic and biochemical changes within the grain. These processes lead to increased levels of gamma-aminobutyric acid (GABA), certain vitamins, and antioxidants, while simultaneously improving functional properties and starch digestibility (He *et al*., 2022; Ma *et al*., 2023; Munarko *et al*., 2021; Ren *et al*., 2022; Sibian *et al*., 2017; Ukpong *et al*., 2023). The GABA content in germinated brown rice has been reported to increase several-fold compared to that in non-germinated brown rice (Summpunn *et al*., 2023). Consequently, germinated brown rice exhibits a higher potential as a functional food than conventional brown rice (Cornejo *et al*., 2015; Nirmagustina *et al.*, 2021).

On the other hand, changes in lifestyle patterns and the increasing participation of women in the workforce have driven the demand for convenient, ready-to-prepare food products that remain nutritionally adequate. Instant rice represents one form of rice product diversification developed to shorten meal preparation time. In general, instant rice is produced by fully cooking rice, followed by drying using specific methods, allowing rapid rehydration prior to consumption (Yadav *et al*., 2024). Various drying technologies and pretreatment methods have been investigated, including autoclaving–freezing, freeze drying, and combined drying techniques, to produce instant rice with a soft texture, short rehydration time, and sensory quality comparable to freshly cooked rice (Banurea *et al*., 2020; Rahmadi *et al*., 2016; Sasmitaloka *et al*., 2019; Wardhani *et al*., 2024; Widowati *et al*., 2020). In addition, instant rice has potential applications as emergency food logistics and as a practical ration for consumers with high mobility.

Previous studies on instant rice have predominantly used white rice or low-amylose rice as raw materials (Sasmitaloka *et al*., 2019, 2020; Wardhani *et al*., 2024). Research specifically utilizing germinated brown rice as the raw material for instant rice remains limited, despite the fact that the integration of germination technology and instant rice processing has the potential to produce products with enhanced nutritional and functional properties while offering improved convenience of preparation (Yadav *et al*., 2024). Moreover, information regarding the physical and chemical profiles of instant rice based on germinated brown rice from local varieties, such as Inpari 32, which is widely cultivated in Subang Regency, is still scarce. Such characterization is essential to evaluate product quality, enable comparison with previous studies, and assess the feasibility of further development as a ready-to-eat functional food product.

Based on the above considerations, this study was conducted to evaluate the physical and chemical profiles of instant rice produced from germinated brown rice of the Inpari 32 variety. Specifically, the study examined key physical parameters, including yield, rehydration properties, bulk density, color, and texture, as well as important chemical components, namely moisture, ash, fat, protein, carbohydrate contents, and selected indicators of bioactive compounds in the resulting instant rice. The findings of this study are expected to provide a scientific basis for the development of nutrient-rich instant rice products based on germinated brown rice, while also serving as a reference for the utilization of the Inpari 32 variety as a raw material for functional food innovation aimed at improving nutritional quality and supporting food security.

2. MATERIALS AND METHODS

2.1. Time and Location of the Study

The study was conducted from May to November 2025 at the Seed Technology Laboratory, Chemistry Laboratory, and Quality Control Laboratory, Department of Agriculture, Subang State Polytechnic, Indonesia.

2.2. Materials and Equipment

The primary material used in this study was paddy rice of the Inpari 32 variety, obtained from CV Agrospora Subang, which was subsequently milled into dry-milled brown rice. The chemicals used included distilled water, mineral water, 5% sodium citrate, 2% iodine solution (I_2), 1 N sodium hydroxide (NaOH), 0.1 N oxalic acid, 0.5 N acetic acid, phenolphthalein (PP) indicator, amylose standard (pro analysis, Merck), and 96% ethanol (pro analysis).

The equipment employed comprised trays, rice straw paper, an analytical balance (Fujitsu), an incubator (IKA), a UV–Vis double-beam spectrophotometer (PG Instruments), a vernier caliper, a 400-mesh sieve, volumetric flasks, pipettes, graduated cylinders, beakers, a gas stove (Rinnai), a water bath, a pressure cooker (Maxim, 4 L), a freezer (LG), baking trays, an oven and muffle furnace (Memmert), a desiccator, porcelain crucibles, burettes, as well as various plastic and glassware accessories used for physical and chemical analyses.

2.3. Experimental Design

The study employed a nested randomized block design. The primary factor was soaking duration of brown rice (12 and 24 h). Germination duration (36, 48, and 60 h) was applied subsequently and nested within each soaking duration level. This design resulted in six treatment combinations replicated three times to have a total of 18 experimental units.

All treated samples were initially processed into germinated brown rice (GBR). Subsequently, a portion of the GBR was further processed into instant germinated brown rice (instant GBR rice) to allow evaluation of their physical and chemical characteristics. Germination testing was conducted using the rolled paper towel method in plastic bags, with each roll containing 25 GBR kernels, resulting in a total of 450 kernels used for the germination test. Kernels were considered germinated when the radicle length reached a minimum of 2 mm. The germination percentage of germinated brown rice (GBR) was calculated by adapting the standard germination capacity formula as described by the International Seed Testing Association (ISTA, 2025), as follows:

$$\text{Germination percentage (\%)} = \frac{\text{Number of germinated kernels}}{\text{Total number of tested kernels}} \times 100 \quad (1)$$

2.4. Procedure for the Preparation of GBR and Instant Rice

Dry-milled paddy rice was milled using a rice milling machine to obtain brown rice. The germination process was conducted following the method described by Nirmagustina *et al.* (2021), with several modifications. A total of 100 g of brown rice was placed in a beaker containing 1 L of water at 40 °C and soaked according to the designated soaking durations (12 and 24 h). After soaking, the rice was drained and evenly spread on trays lined with rice straw paper, then incubated in an incubator at 40 °C with a relative humidity of approximately 90% for the specified germination durations (36, 48, and 60 h).

During incubation, the samples were periodically sprayed with water to maintain moisture, prevent fermentation, and minimize the formation of off-flavors. Upon completion the germination, the germinated brown rice was washed and subjected to oven drying at 80 °C for 15 min to terminate enzymatic activity, followed by further drying at 60 °C until the moisture content reached ≤14% (Parnsakhorn & Langkapin, 2018). The product obtained at this stage was referred to as germinated brown rice (GBR) and was subsequently used as the raw material for instant rice production.

Instant rice was prepared from germinated brown rice by weighing 200 g of the sample, which was then subjected to soaking in a 5% sodium citrate solution at a rice-to-solution ratio of 1:2 (w/v) for 2 h. After soaking, the rice was rinsed and washed with water at a ratio of 1:2 (w/v) three times to remove residual sodium citrate solution and adhering impurities. Subsequently, the rice was cooked using a pressure cooker at a rice-to-water ratio of 1:1.5 for 12 min. The cooked rice was then placed in a freezer at −20 °C for 24 h (Yadav *et al*., 2024). After freezing, the rice was subjected to a thawing process at 60 °C for 15 min. The rice grains were then gently separated and evenly spread on baking trays to prevent agglomeration. Subsequently, the rice was dried in a hot-air oven at 60 °C for 6 h to obtain instant rice. The resulting instant rice was stored in airtight containers until further physical and chemical analyses.

2.5. Analysis of Physical and Chemical Characteristics of GBR and Instant Rice

The analysis of germinated brown rice (GBR) focused on germination percentage, moisture content, ash content, and amylose content. Germination percentage was determined based on the proportion of normal radicle emergence, following the procedure described by Nurrachmamila & Saputro (2017). Moisture content of GBR was measured using the oven-drying method at 105 °C until a constant weight was achieved (Parnsakhorn & Langkapin, 2018). For instant germinated brown rice, analyses covered physical, chemical, and sensory characteristics. Physical parameters included bulk density, moisture content, ash content, and amylose content. These parameters were determined referring to procedures reported by Wardhani *et al*. (2024), Nirmagustina *et al.* (2021), and Sasmitaloka *et al*. (2020).

2.6. Statistical Analysis

All experimental data were analyzed using analysis of variance (ANOVA) appropriate for a nested design at a 5% significance level. The effects of soaking duration and germination duration nested within soaking were evaluated. When significant differences were detected, mean comparisons were performed using Duncan's Multiple Range Test (DMRT) at a $\alpha = 0.05$.

3. RESULTS AND DISCUSSION

3.1. Germinated Brown Rice

3.1.1. Yield

The yield of germinated brown rice (GBR) represents the percentage of GBR obtained after soaking and germination relative to the initial weight of brown rice. As shown in Table 1, soaking duration and germination duration did not significantly affect the yield of the resulting GBR. The yield values ranged from 83.00 to 86.67%.

Although soaking and germination durations influence water imbibition and metabolic activity within the grain, these processes did not result in a significant loss of dry matter during treatment. The milling of brown rice retains the aleurone layer and bran, thereby preserving the structural integrity of the grain and contributing to relatively stable yield values. This finding is consistent with previous studies reporting that soaking durations of up to 6 h and germination periods of approximately 40 h significantly increased γ-aminobutyric acid (GABA) content without causing substantial solid mass loss (Hussain *et al*., 2020).

Table 1. Yield of germinated brown rice

Soaking duration (h)	Germination duration (h)	Yield			
		Mean (%)*	Minimum (%)	Maximum (%)	SD
12	36	84.00	78.23	89.77	3.50
12	48	83.00	77.23	88.77	4.44
12	60	86.67	80.89	92.44	4.64
24	36	85.33	79.56	91.11	5.84
24	48	83.00	77.23	88.77	6.08
24	60	86.00	80.23	91.77	1.32

* No significant differences were observed among treatments based on ANOVA ($p > 0.05$).

3.1.2. Radicle Emergence and Radicle Length

Radicle emergence was used as a parameter to determine the proportion of germinated rice grains. Radicle emergence is a standard indicator for assessing germination capacity and potential field emergence performance (International Seed Testing Association, 2025). Although the germinated brown rice in this study was not intended for use as seed, the germination process was expected to enhance nutritional quality and improve certain physical characteristics of rice, such as texture and palatability. The treatments and combinations of soaking duration and germination duration did not result in significant differences in the percentage of germinated rice, as indicated by radicle emergence (Table 2). This suggests that, within the range of conditions applied, the initial soaking time and subsequent germination period were sufficient to initiate germination uniformly without markedly affecting the proportion of grains exhibiting radicle development.

Table 2. Percentage of germinated brown rice as affected by soaking duration and germination duration

Germination duration (h)	Soaking duration 12 h (%)	Soaking duration 24 h (%)	Mean (%)
36	29.33 ± 14.05	30.67 ± 10.06	30 ± 10.95
48	46.67 ± 16.16	46.67 ± 15.14	46.67 ± 14.01
60	37.33 ± 8.33	53.33 ± 28.94	45.33 ± 20.96
Mean (%)	37.78 ± 13.72	43.55 ± 19.84	40.67 ± 16.82

Note: Values are presented as mean ± standard deviation. No significant differences were observed among treatments based on ANOVA ($p > 0.05$).

The loss of the seed coat in germinated brown rice is presumed to be one of the factors contributing to the relatively low germination percentage observed in this study. The seed coat plays a crucial role in protecting the seed from mechanical damage and preventing the loss of essential components required for normal germination. According to Andini *et al*. (2021), damage to the cell membrane—such as that caused by the absence of the seed coat in dehulled rice—can lead to the leakage of electrolytes and soluble sugars, resulting in reduced metabolic activity and, consequently, diminished physiological capacity for germination.

In addition to the absence of the seed coat, the relatively high variability among replicates is likely influenced by differences in the physical condition of the brown rice kernels used. Brown rice does not constitute an intact seed; therefore, the extent of microstructural damage, such as embryo fractures, fine cracks, and abrasion of the aleurone layer, may vary among individual kernels. Variations in surface structure and internal integrity strongly affect water imbibition capacity and cell membrane stability during the initial stages of germination. The absence of significant differences among treatments indicates that a soaking duration of 12 h combined with a germination period of 36 h represents the most efficient treatment condition for producing germinated brown rice.

Figure 1. Radicle emergence of brown rice in 12 h soaking duration and 36 h germinated duration

The decline in the physiological capacity of brown rice to germinate was also reflected in the radicle length observed under each treatment condition (Table 3). The relatively low germination capacity and short radicle length obtained in this study are presumed to be associated with excessively long soaking durations (12–24 h). In the absence of the seed coat, cell membranes become more susceptible to damage during soaking. However, the extent of such damage may vary among individual kernels, resulting in heterogeneous metabolic activity required to induce radicle growth. Previous research on germinated brown rice (Permatasari *et al*., 2025), reported that an initial soaking duration of 4 h was sufficient to initiate imbibition, leading to a germination percentage of up to 86% within 12 h of incubation in a germinator. Prolonged soaking may increase the risk of over-imbibition in some kernels, inducing hydration stress and exacerbating variability in germination responses among brown rice grains. Despite these tendencies, the differences among treatment combinations in the present study were not statistically significant.

Table 3. Radicle length of GBR as affected by soaking duration and germination duration

Germination duration (h)	Soaking duration 12 h (mm)	Soaking duration 24 h (mm)	Mean (mm)
36	0.38 ± 0.19	0.86 ± 0.04	0.62 ± 0.29
48	0.89 ± 0.53	0.85 ± 0.37	0.87 ± 0.41
60	1.18 ± 1.35	1.37 ± 0.81	1.28 ± 1.00
Mean (mm)	0.82 ± 0.81	1.02 ± 0.51	0.92 ± 0.69

Note: Values are expressed as mean ± standard deviation. No significant differences were observed among treatments based on ANOVA ($p > 0.05$).

3.1.3. Moisture Content

Moisture content is a critical quality parameter in food materials, as it influences appearance and shelf life (Afistia *et al*., 2024). As presented in Table 4, germination duration had a significant effect on the moisture content of germinated brown rice, whereas soaking duration did not exert a significant influence. Germination for 60 h resulted in the highest moisture content (8.79%), whereas germination for 36 and 48 h showed no differences in moisture content, ranging from 6.12 to 6.15%. The increase in moisture content was influenced by the germination process, which triggered metabolic activity in rice kernels through water absorption via imbibition. The presence of water is essential to support

Table 4. Moisture content of germinated brown rice

Germination duration (h)	Soaking duration 12 h (%)	Soaking duration 24 h (%)	Mean (%)
36	6.19 ± 0.06	6.11 ± 0.04	6.15 ± 0.06[a]
48	6.05 ± 0.06	6.19 ± 0.15	6.12 ± 0.13[a]
60	8.78 ± 0.02	8.80 ± 0.06	8.79 ± 0.04[b]
Mean (%)	7.01 ± 1.37	7.03 ± 1.37	7.02 ± 1.31

Note: Values are expressed as mean ± standard deviation. Different superscript letters within the Mean column indicate significant differences among germination durations based on Duncan's Multiple Range Test (DMRT) at α = 0.05.

enzymatic activity involved in the hydrolysis of starch and protein reserves into simpler compounds required for embryo growth (Zhao *et al*., 2020). According to the Indonesian National Standard for rice (SNI 6128-2020), the maximum allowable moisture content of rice is 14% (BSN, 2020); therefore, the germinated brown rice produced in this study complied with the established standard.

3.1.4. Ash Content

Ash content represents the total mineral content present in a material (Pangerang, 2022). As shown in Table 5, germination duration had a significant effect on the ash content of germinated brown rice. The highest ash content was observed at a germination duration of 60 h (0.75%), while the lowest ash content was recorded at 48 h of germination (0.52%). These findings are consistent with a study on germinated brown rice of the Pusa Basmati 1121 variety (Sood *et al*., 2024), which showed that ash content increased to 1.57% after 12 h of soaking followed by 48 h of germination, attributed to increased levels of minerals such as Fe, Ca, Mg, and K. The germination process enhances mineral content as enzymatic activity breaks down complex compounds, thereby increasing mineral availability to support growth processes (Kaur & Asthir, 2021). Similar results were also reported in an instant rice study (Sasmitaloka *et al*., 2020), which showed ash contents of 0.53% for Inpari 32, 0.79% for IR 42, and 0.61% for Sintanur milled rice, all of which fall within the typical ash content range of milled rice.

Table 5. Ash content of germinated brown rice

Germination duration (h)	Soaking duration 12 h (%)	Soaking duration 24 h (%)	Mean (%)
36	0.65 ± 0.07	0.73 ± 0.08	0.69 ± 0.06[ab]
48	0.55 ± 0.16	0.49 ± 0.11	0.52 ± 0.12[a]
60	0.66 ± 0.08	0.84 ± 0.06	0.75 ± 0.12[b]
Mean (%)	0.62 ± 0.10	0.69 ± 0.17	0.65 ± 0.14

Note: Values are expressed as mean ± standard deviation. Different superscript letters within the Mean column indicate significant differences among germination durations based on Duncan's Multiple Range Test (DMRT) at α = 0.05.

3.2. Instant Rice Based on Germinated Brown Rice

3.2.1. Bulk Density

Bulk density of instant rice is closely related to its porosity. Lower bulk density indicates higher porosity (Kurniasari *et al*., 2020). Increased porosity facilitates water penetration into the pores of instant rice during rehydration, thereby shortening rehydration time. As shown in Table 6, neither soaking duration nor germination duration nested within soaking significantly affected the bulk density of instant rice. The bulk density of instant rice ranged from 0.30 to 0.44 g/mL, indicating that the instant rice possessed relatively high porosity. These values were lower than those reported

Table 6. Bulk density of instant rice made from germinated brown rice

Germination duration (h)	Soaking duration 12 h (g/mL)	Soaking duration 24 h (g/mL)	Mean (g/mL)
36	0.44 ± 0.06	0.36 ± 0.03	0.40 ± 0.05
48	0.43 ± 0.06	0.33 ± 0.10	0.38 ± 0.09
60	0.30 ± 0.05	0.42 ± 0.04	0.36 ± 0.07
Mean (g/mL)	0.39 ± 0.08	0.37 ± 0.07	0.38 ± 0.07

Note: Values are expressed as mean ± standard deviation. No significant differences were observed among treatments based on ANOVA ($p > 0.05$).

in a previous study using the same rice variety without soaking and germination treatments, which resulted in a bulk density of 0.57 g/mL (Sasmitaloka *et al*., 2020). Soaking treatment using sodium citrate prior to cooking increased the formation of pores in the instant rice, as it can disrupt the rice protein structure, thereby reducing bulk density. The formation of a greater number of pores increases the available surface area for water absorption during rehydration.

3.2.2. Moisture Content

As shown in Table 7, neither germination duration nor soaking duration had a significant effect on the moisture content of instant rice produced from germinated brown rice. The moisture content of instant rice obtained in this study ranged from 5.65% to 8.65%. The maximum acceptable moisture content for instant rice is reported to be in the range of 9.0–12.5% (Sasmitaloka *et al*., 2020). Therefore, the instant rice produced in this study remained below the maximum allowable range and can be classified as suitable for consumption.

Table 7. Moisture content of instant rice made from germinated brown rice

Germination duration (h)	Soaking duration 12 h (%)	Soaking duration 24 h (%)	Mean (%)
36	6.18 ± 1.29	7.13 ± 1.52	6.66 ± 1.36
48	5.65 ± 0.50	7.45 ± 2.37	6.55 ± 1.83
60	7.88 ± 1.66	8.65 ± 2.61	8.27 ± 1.99
Mean (%)	6.57 ± 1.48	7.74 ± 2.04	7.16 ± 1.83

Note: Values are expressed as mean ± standard deviation. No significant differences were observed among treatments based on ANOVA ($p > 0.05$).

Table 8. Ash content of instant rice made from germinated brown rice

Germination duration (h)	Soaking duration 12 h (%)	Soaking duration 24 h (%)	Mean (%)
36	1.15± 0.13	0.67 ± 0.22	0.91 ± 0.31
48	0.98 ± 0.17	0.73 ± 0.41	0.85 ± 0.31
60	0.96 ± 0.10	0.72 ± 0.15	0.84 ± 0.17
Mean (%)	1.03 ± 0.15	0.71 ± 0.25	0.86 ± 0.26

Note: Values are expressed as mean ± standard deviation. No significant differences were observed among treatments based on ANOVA ($p > 0.05$).

3.2.3. Ash Content

As shown in Table 8, neither germination duration nor soaking duration had a significant effect on the ash content of germinated brown rice. The ash content of instant rice obtained in this study ranged from 0.96% to 1.15%. This ash content was higher than that reported in previous studies, including Banurea *et al*. (2020), which reported ash contents ranging from 0.17% to 0.34%; Widowati *et al*. (2020), which reported an ash content of 0.41%; and Syamarta (2021), which reported values ranging from 0.29% to 0.40%.

A high ash content indicates a high mineral content in the product (Pangerang, 2022). Brown rice is known to contain relatively high levels of minerals such as magnesium, potassium, and manganese; therefore, instant rice based on brown rice tends to exhibit higher ash content (Sulistyowati *et al*., 2020).

3.2.4. Amylose Content

Amylose content was determined spectrophotometrically at a wavelength (λ) of 620 nm. The standard calibration curve used for amylose determination is presented in Figure 2. The coefficient of determination (R^2) of 0.9907 indicates a strong positive correlation between absorbance and amylose content. Higher absorbance values correspond to higher amylose content in the sample.

Based on Table 9, soaking duration (12–24 h) and germination duration (36–60 h) did not result in significant differences in the amylose content of instant rice based on germinated brown rice ($p > 0.05$). The amylose content of instant rice based on brown rice ranged from 16.82% to 22.14%. A germination duration of 60 h resulted in the lowest mean amylose content (18.56%) and was associated with a relatively high standard deviation (SD). The high variability among replicates is presumed to be influenced by differences in hydration level, the degree of partial gelatinization during the drying process, or sample heterogeneity during aliquot collection for spectrophotometric analysis. Variations

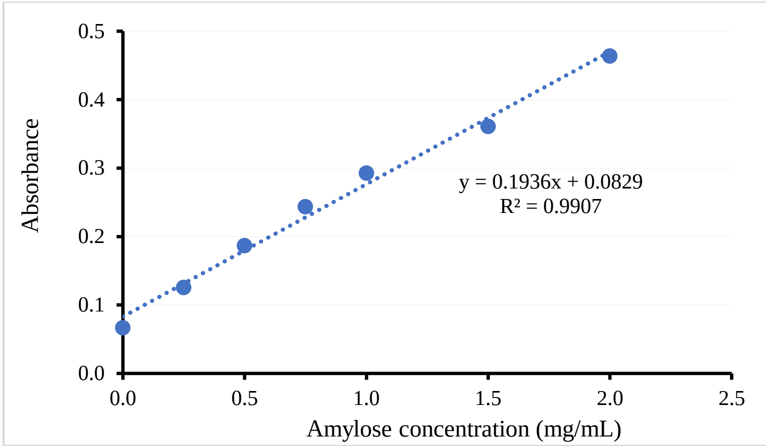

Figure 2. Standard calibration curve for amylose determination in instant rice

Table 9. Amylose content of instant rice made from germinated brown rice

Germination duration (h)	Soaking duration 12 h (%)	Soaking duration 24 h (%)	Mean (%)
36	20.02 ± 2.54	20.37 ± 2.23	20.19 ± 2.15
48	22.14 ± 4.62	21.99 ± 3.07	22.06 ± 3.51
60	20.31 ± 0.64	16.82 ± 5.98	18.56 ± 4.26
Mean (%)	20.82 ± 2.84	19.73 ± 4.21	20.28 ± 3.53

Note: Values are expressed as mean ± standard deviation. No significant differences were observed among treatments based on ANOVA ($p > 0.05$).

in the structural properties of rice grains following rehydration and drying may affect starch extraction efficiency and the reactivity of the amylose–iodine complex during measurement.

Increased α-amylase activity with prolonged germination duration is known to accelerate starch hydrolysis into simpler sugars (Wang *et al*., 2024). Although a decreasing trend in amylose content was observed in the present study, the differences among treatments were not statistically significant. The amylose content obtained in this study was lower than that reported for milled Inpari 32 rice (23.77%) (Sasmitaloka *et al*., 2020). These differences may be attributed to variations in the characteristics of the raw material and the processing conditions applied during instant rice production.

4. CONCLUSIONS AND RECOMMENDATIONS

This study demonstrated that variations in soaking duration (12–24 h) and germination duration (36–60 h) resulted in a relatively stable yield of germinated brown rice (83.00–86.67%). Germination duration increased the moisture and ash contents of germinated brown rice; however, these values remained within the limits specified by the Indonesian National Standard (SNI). Instant rice produced from germinated brown rice exhibited low bulk density (indicating high porosity), which is favourable for rehydration, moisture content below the maximum allowable limit, and relatively high ash content reflecting good mineral composition.

Although germination percentage and radicle length were relatively low due to the prolonged soaking conditions applied, a soaking duration of 12 h combined with a germination duration of 36 h can be recommended as the most efficient treatment combination. For future studies, optimization of soaking and germination conditions is required to improve germination performance while maintaining desirable physical quality attributes. Sample homogenization is also recommended to reduce data variability. In addition, further investigation of functional nutritional components (e.g., GABA and essential minerals), along with sensory evaluation and consumer acceptance tests, is necessary to enhance the readiness of instant rice technology based on germinated brown rice for industrial-scale application.

ACKNOWLEDGEMENTS

The authors would like to express their sincere gratitude to the Research and Community Service Center (P3M), Subang State Polytechnic (POLSUB), for the financial support provided for this research through Grant No. 2008/PL41.R6/AL.04/2025. The authors also express their appreciation to the Department of Agriculture, POLSUB, for providing laboratory facilities and technical assistance.

AUTHOR CONTRIBUTION STATEMENT

Author	C	M	So	Va	Fo	I	R	D	O	E	Vi	Su	P	Fu
DT	✓			✓					✓	✓				
FA	✓	✓			✓	✓	✓	✓	✓	✓				
ES	✓	✓										✓	✓	✓
RF	✓									✓	✓			

C: Conceptualization	Fo: Formal Analysis	O: Writing - Original Draft	Fu: Funding Acquisition
M: Methodology	I: Investigation	E: Writing - Review & Editing	P: Project Administration
So: Software	D: Data Curation	Vi: Visualization	
Va: Validation	R: Resources	Su: Supervision	

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