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Physicochemical and Functional Characteristics of Analog Rice Made from Local Cassava and Red Kidney Bean

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ABSTRACT

Nuabosi cassavas and Inerie red kidney beans are local foods from East Nusa Tenggara whose processing is relatively limited, but they have the potential to be developed into analog rice. This study aims to determine the effects of various compositions of Nuabosi cassava flour and Inerie red kidney bean flour on the characteristics of the produced analog rice. The procedure was conducted in three main stages: the preparation of cassava flour and red beans, formulation and production, and analysis. Various compositions of Nuabosi cassavas flour and Inerie red kidney beans were used: 98:0 (A); 88:10 (B); 83:15 (C); 78:20 (D); 73:25 (E). The data were analyzed by ANOVA, followed by DMRT at a 5% significance level. The results of the study showed, analog rice sample D (78% cassavas flour: 20% red kidney beans flour) has the best physicochemical and antioxidant activity characteristics of all samples. Furthermore, the sensory analysis results showed that most panelists had started to like the aroma, taste, and texture of analog rice made from 78% cassavas flour and 20% red kidney beans flour. Analog rice made from Nuabosi cassavas and Inerie red kidney beans has the potential to be developed as a functional food.

1. INTRODUCTION

For most of the Asian population, especially Indonesians, rice is considered as a staple food. More than 90% of people in Indonesia depend on rice as their daily staple food (Afriyani *et al*., 2021). The increasing population of Indonesia has resulted in a high demand for rice, which is not supported by an increase in its productivity, resulting in the government's decision to import it from various neighboring countries (Anggraeni, 2020; Ansari *et al*., 2023). Low rice production in Indonesia has become a serious food security problem in this country, this is due to the lack of conversion of rice fields and climate change which has an impact on extreme drought (Förster *et al*., 2011).

The problem of food conditions in Indonesia is exacerbated by various health problems originating from the sources of food consumed. Based on the results of the Indonesian Basic Health Research in 2018 the prevalence of degenerative diseases in the country is relatively high, particularly diabetes mellitus, hypertension, stroke, cancer, and chronic kidney disease (Arifin *et al*., 2022; Liberty *et al*., 2024). This increase is closely associated with lifestyle changes among the population, including unhealthy diets, lack of physical activity, rising obesity rates, and smoking habits. A healthy diet is needed to maintain physical fitness and avoid degenerative diseases. As a staple food, rice has been identified as containing 78.9% carbohydrates, 6.8% protein, and 0.8% iron (Dalbhagat *et al*., 2019). However, the nutritional components and bioactive compounds of rice are not sufficient to meet the nutritional needs to maintain body health. Indonesia has potential sources of carbohydrates from various tubers and grains. The development of food diversification based on functional foods is expected to overcome the problem of people's dependence on rice and satisfy the demand for functional foods. One of the efforts is to produce analog rice sourced from local varieties of cassava (*Manihot esculenta* Crantz) and red kidney beans (*Phaseolus vulgaris* L.).

Analog rice is known as a functional food product in the form of rice grains that can be produced from non-rice flour (Noviasari *et al*., 2017). Numerous studies have examined analog rice made from various ingredients, such as purple sweet potato (Wang *et al*., 2001), arrowroot (Darmanto *et al*., 2022), and cassava (Kusumayanti *et al*., 2022). Apart from being a source of carbohydrates, cassava also contains various bioactive compounds like hydroxycoumarins, terpenoids, phenolic acids, flavonoids, and tannins (Priska *et al*., 2020), thus having the potential to improve the health of patients with degenerative diseases, especially if combined with red kidney beans which are also rich in bioactive components, such as: saponin, phenolic compounds, flavonoids, and anthocyanins (Chávez-Mendoza & Sánchez, 2017; Widiawati *et al*., 2022). East Nusa Tenggara Province has local varieties of cassava and red kidney beans that are well-known for their various advantages, namely Nuabosi cassavas and Inerie red kidney beans; both have been consumed by almost all people in this province and even in other parts of Indonesia (Lewar *et al*., 2020; Mutiara & Bolly, 2019; Ngongo *et al*., 2022). Red kidney bean has the potential to be diversified into functional foods since it is a great source of vegetable protein, minerals, and fiber (Guo *et al*., 2021).

On Flores Island, two food crop commodities cassava and red kidney beans continue to be developed. Nuabosi cassava is one variety of cassava renowned for its superiority as a tasty and juicy food. In addition, its nutritional content, including carbohydrates, protein, and sufficient fiber, further enhances its superiority (Priska *et al*., 2020). Inerie red beans contain protein and vegetable fats, that have the potential to be used as functional food ingredients (Lewar *et al*., 2018). Nuabosi cassava is only grown in several areas in Ende Regency (Pu'u, 2019) and has been registered as a local variety (Mutiara & Bolly, 2019). Furthermore, Statistics of Nusa Tenggara Timur Province, reported NTT's cassava production of 574,413 tons in 2022, while red kidney bean production reached 11,986 tons (BPS, 2022). Despite the high yield of cassava and red kidney beans in this province, their utilization is not at its peak. These two local food commodities can only be processed traditionally due to a lack of technology and knowledge. Cassava is often processed by boiling it or making it into chips, which are low in functional compounds. Likewise, red kidney beans are only used in soup. Therefore, efforts must be made to diversify cassava and red kidney bean products into analog rice, which is rich in nutritional components and functional qualities, making it beneficial for community health. In addition, food diversification also affects the achievement of sustainable food stability, considering that NTT is one of the provinces with food insecurity status and food nutrition problems. This issue undoubtedly necessitates an effort to diversify food using Nuabosi cassava and Inerie red kidney beans. Research on analog rice had been widely conducted using various alternative raw materials. However, the use of local food ingredients, particularly from NTT, in the production of analog rice had never been explored.

The utilization of local ingredients as the primary source aims to enhance food availability based on local resources, reduce dependence on imported materials, and promote food diversification. Analog rice made from the best combination of Nuabosi cassava flour and Inerie red kidney bean flour is expected to be an alternative staple food that meets carbohydrate needs and has functional capabilities as seen from its physicochemical characteristics, sensory properties, and antioxidant activity.

2. RESEARCH METHODS

The materials used in this study were local varieties of cassavas (Nuabosi) and red kidney beans (Inerie) obtained from community plantations in Ende Regency and Bajawa Regency, Flores Island, East Nusa Tenggara Province, Indonesia, with harvest ages of 10 months and 70 days respectively. Glycerol Monostearate (GMS) (food grade), water (Aqua), Amylose (Sigma), H_2SO_4 (Merck), NaOH (Merck), gallic acid (Merck), folin reagent (Merck), bovine serum albumin (Sigma), $CuSO_4$ (Merck), Ethanol 96% (Merck), 2,2-diphenyl-1-picrylhydrazyl (DPPH) (Sigma).

2.1. Flour Preparation

The steps for preparing cassava flour were modified from the method proposed by Elisabeth *et al*. (2022). The obtained cassava samples were cleaned of the outer skin, washed, and soaked in water for one hour. After that, the samples were manually sliced transversely and dried using an oven (Memert) for 48 hours at a temperature of 60°C. The dried samples were ground using a flour milling machine and sieved using an 80-mesh sieve. Meanwhile, the red kidney bean flour was made by first washing the red kidney bean samples, soaking them in water for 12 h, and steaming them over medium heat for 30 min at 55°C. According to Agustina *et al*. (2013), steaming and soaking are necessary to reduce the gas-producing ability of red kidney beans, which can cause bloating. Then, the samples were dried using an oven for 48 h at a temperature of 60°C. After drying, the samples were ground using a flour milling machine and sieved using an 80-mesh sieve.

2.2. Analog Rice Formulation and Production Process

Cassava and red kidney bean sample flours were formulated in different ranges as seen in Table 1 with the addition of 2% Glyceryl Monostearate (GMS) and 50% water from the weight of the flour (Noviasari *et al*., 2017). There were five formulation treatments, each repeated three times, resulting in 15 treatment combinations in a completely randomized design (CRD). After that, the formulated materials went through the analog rice production process using the granulation method to minimize the degradation of its nutritional and bioactive components (Hidayat *et al*., 2017). The granulation method for analog rice was conducted through the following steps: The flour was mixed according to the treatment formulation (Table 1). The dough was then shaped using an electric pasta machine and cut into 3 mm pieces to resemble rice. After that, it was steamed at 70°C for 6 minutes to achieve gelatinization. The analog rice was then cooled and dried in a drying cabinet at 50°C for 6 hours.

Table 1. Analog rice treatment formulation

Material	Treatments				
	A	B	C	D	E
Nuabosi cassava flour (%)	98	88	83	78	73
Inerie red kidney beans (%)	0	10	15	20	25
Glycerol monostearate (GMS) (%)	2	2	2	2	2

2.3. Nutritional Component Analysis

The analog rice was tested for its nutritional components, including proximate, crude fiber content (AOAC, 2006).

2.3.1. Rehydration Analysis

Rehydration analysis refers to the modification of the method by Handayani *et al*. (2017). One gram of the analog rice sample powder was homogenized with 10 mL of distilled water in a centrifuge tube using a vortex. The sample was centrifuged at a speed of 2000 rpm for 20 minutes. The resulting supernatant was separated, and the centrifuge tube was weighed. Then, the rehydration capacity was calculated with formula 1:

$$Rehydration\ Power = \frac{initial\ volume\ of\ water - supernatant\ volume}{sample\ weigh} \quad (1)$$

2.3.2. Texture Analysis

Samples of analog rice grains that have been cooked were tested for texture with a hardness test using a texture analyzer (AMETEK Brookfield). Samples of analog rice grains that have been cooked were tested for texture with a hardness test using a texture analyzer (AMETEK Brookfield). The sample were pressed using a probe at a speed of 0.5 mm/s and deformation value of 0.2 mm. Then, the displayed hardness value was observed (Handayani *et al*., 2017).

2.3.3. Scanning Electron Microscope (SEM) Analysis

The morphological appearance of analog rice samples was observed using SEM (Hitachi FlexSEM 1000, Japan). The cross-sectioned analog rice were placed on the sample holder. Then, the samples were coated with Au-Pd, after which SEM testing was conducted. The samples were observed at 1000x and 3000x magnifications (Kusumayanti *et al*., 2022).

2.4. Sensory Analysis

Five grams of cooked analog rice were served with randomly coded samples to 25 untrained panelists, evaluating attributes of taste, aroma, texture, and overall. The panelists were recruited from the students of the Food Technology program at Unwira. The samples were first given random codes, and then the panelists were asked to fill them based on their level of preference using a 5-point hedonic scale: 1 (dislike), 2 (dislike slighly), 3 (neutral), 4 (like slightly), and 5 (like) (Ramadhan *et al*., 2024).

2.5. Analysis of Total Phenolic and Antioxidant Activity

Analysis of total phenolic content was carried out based on the method of Poonsri *et al*. (2019). Samples were measured using the Folin-Ciocalteu method, and phenolic content was expressed in gallic acid equivalents (mg GAE/100 g of sample). 1mL of sample was mixed with 5 mL of diluted Folin-Ciocalteu reagent, 4.5 mL of 7.5% (w/v) Na_2CO_3, and distilled water, then incubated in the dark for 1 hour. After that, the absorbance of the sample was measured using a UV-Vis spectrophotometer (Genesys) at a wavelength of 760 nm.

Analysis of antioxidant activity capability employed the method developed by Singh *et al*. (2009), with slight modifications. 1 mL sample was mixed with 3 mL of 96% ethanol. The solution was then added to 1 mL of 0.2 mM DPPH, vortexed, and incubated in the dark for 30 minutes at room temperature. Absorbance was measured at 517 nm using a spectrophotometer and calculated using the formula 2:

$$DPPH\ Inhbition\ (\%) = \frac{Abs_{control} - Abs_{sample}}{Abs_{control}} \times 100 \quad (2)$$

2.6. Statistical Analysis

The data for nutritional analysis, rehydration, texture analysis, sensory evaluation, and total phenolic and antioxidant activity analysis were processed using one-way analysis of variance (ANOVA), followed by Duncan's post hoc test for mean separation.

3. RESULTS AND DISCUSSION

The appearances of analog rice produced by the granulation method from different combinations of Nuabosi cassavas and Inerie red kidney beans are shown in Figure 1. The produced analog rice had a shape that closely resembled regular rice, with a pale white color observed in almost all treatment groups. The color of the analog rice was influenced by its main ingredients: Nuabosi cassava, which exhibited a naturally white characteristic, and red beans as a complementary ingredient. The greater the addition of red bean flour, the darker the color tended to be. Then, the produced analog rice was tested for its physical characteristics and nutritional components.

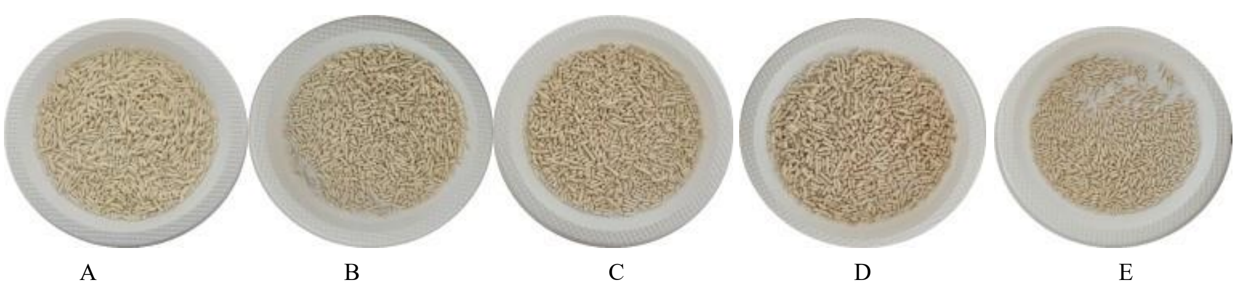


Figure 1. Analog rice from Nuabosi cassavas and Inerie red kidney beans with various flour composition ratios (A= 98:0, B= 88:10, C= 83:15, D= 78:20, E= 73:25)

3.1. Characteristics of Nutritional Components of Analog Rice

The nutritional components of analog rice include various proximate parameters, i.e., moisture content, ash content, fat content, protein content, carbohydrate content, crude fiber content, and amylose content (Table 2).

Table 2. Results of proximate value measurements of analog rice from Nuabosi cassavas and Inerie red kidney beans

Parameters	Treatments				
	A (98%:0%)	B (88%:10%)	C (83%:15%)	D (78%:20%)	E (73%:25%)
Moisture content (%)	7.64 ± 0.18[a]	9.60 ± 0.11[b]	12.02 ± 0.84[c]	13.18 ± 0.03[d]	13.29 ± 0.12[d]
Ash content (%)	2.05 ± 0.25[a]	2.57 ± 0.07[b]	2.61 ± 0.18[b]	2.86 ± 0.03[bc]	3.04 ± 0.11[c]
Fat content (%)	0.56 ± 0.10[a]	2.809 ± 0.16[b]	4.156 ± 0.38[c]	4.55 ± 0.72[c]	6.19 ± 0.35[d]
Protein content (%)	2.75 ± 0.01[a]	5.248 ± 0.09[b]	5.949 ± 0.26[c]	5.89 ± 0.09[c]	8.71 ± 0.15[d]
Carbohydrate content (%)	86.98 ± 0.31[a]	79.76 ± 0.33[b]	75.26 ± 0.56[c]	73.51 ± 0.67[d]	68.76 ± 0.20[e]
Crude fiber content (%)	9.29 ± 0.06[a]	13.09 ± 0.03[b]	13.56 ± 0.04[c]	26.08 ± 0.03[d]	29.39 ± 0.04[e]
Amylose content (%)	25.26 ± 0.11[a]	26.11 ± 0.03[b]	27.04 ± 0.48[c]	28.17 ± 0.04[d]	28.74 ± 0.17[e]

Note: The mean value ± SD followed by different letters in the same row indicates a significant difference at $p<0.05$ level based on DMRT.

3.1.1. Moisture Content

The moisture content of a food product has a crucial role in determining its shelf (Zambrano *et al*., 2019). High moisture content in a certain food product will accelerate the deterioration of the product due to contamination by various microorganisms (Los *et al*., 2018; Sofiah *et al*., 2022). Moisture content provides an environment that supports the growth of microorganisms. According to Ferdian *et al*. (2019), an increase in water content in a product tends to raise the water activity (a_w). At specific a_w values, the growth of microorganisms, such as fungi, can be supported.

The combination of Nuabosi cassava flour and Inerie red kidney bean flour significantly affected ($p<0.05$) the moisture content of the produced analog rice. The moisture content values ranged from 7.64–13.29% (Table 2). The range of moisture content values of analog rice produced in this study has met the optimum value set in the Indonesian National Standard of SNI 01-6128-2008, namely <14%. The moisture content of analog rice can be determined by the components of the raw materials, the amount of water used, and the drying method employed in the production process (Putri *et al*., 2023). The results of this study indicate a tendency for moisture content to increase along with the greater composition of red kidney bean flour. Furthermore, the relationship between the proximate components and the moisture content in food products is likely to be associated with the interactions of bonds formed between the compounds used (Soekarto & Adawiyah, 2012).

3.1.2. Ash Content

The ash content value indicates the amount of mineral content in analog rice. The composition of Nuabosi cassava flour and Inerie red kidney bean flour significantly influenced ($p<0.05$) the ash content of the produced analog rice. The ash content values ranged from 2.05%–3.04% (Table 2). The addition of red kidney bean flour had a significant impact on increasing the ash content of analog rice. The raw materials used are suspected to affect the mineral content of the produced analog rice. Based on the findings of previous studies, the ash content of red kidney bean flour is 2.7% (Ratnawati *et al*., 2019), while that of cassava flour is 1.03% (Elisabeth *et al*., 2022). In this study, analog rice produced from a combination of Nuabosi cassava flour and Inerie red kidney bean flour has a higher ash content than that of regular rice, namely 0.20% (Putri & Sumardiono, 2020).

3.1.3. Fat Content

Table 2 shows the fat content of the produced analog rice samples, which ranged from 0.56–6.19%. There was a significant difference ($p<0.05$) in the fat content of each formulation. The fat content of analog rice is suspected to be due to the raw materials used, namely red kidney beans. Red kidney bean flour is a source of fat, ranging from 1.11 to 3.20% (Ratnawati *et al*., 2019). Vegetable fat in food products has benefits in maintaining intestinal microflora and is also an indicator of a low glycemic index (Muralidharan *et al*., 2019; Wahjuningsih & Susanti, 2018).

3.1.4. Protein Content

The protein content of the produced analog rice samples ranged from 2.75–8.71% (Table 2). There was a significant difference ($p<0.05$) in the protein content of each formulation. Similar to the fat content, the protein content of analog rice is suspected to be influenced by the raw materials used, namely red kidney beans. Ratnawati *et al*. (2019) reported that the protein content of red kidney bean flour reached 22.53%. Meanwhile, according to Lewar *et al*. (2018), the protein content of Inerie Red kidney beans reached 18.76%. Aside from the raw materials, the granulation method used in the production of analog rice can minimize protein degradation due to hot temperatures and friction from the extruder machine (Hidayat *et al*., 2017).

In functional foods, the high protein content of the raw materials contributes to a low glycemic index (GI) and helps slow down the rate of digestion and intestinal absorption (Aller *et al*., 2014). Based on the GI values, foods are categorized into low GI (<10), medium GI (56-69), and high GI (>70). The higher GI of a food, the greater its potential to raise blood glucose levels (Zhang *et al*., 2021). The mechanism of protein in lowering blood glucose levels has been reported. According to Probosari (2019), protein can stimulate insulin secretion in the blood, thereby increasing glucose absorption into body cells. Huicui *et al*. (2017), added that high-protein foods can trigger the secretion of cholecystokinin (CCK), gastric inhibitory polypeptide (GIP), and glucagon-like peptide-1 (GLP-1), which contribute to the feeling of satiety.

3.1.5. Carbohydrate Content

The highest carbohydrate content was found in analog rice sample A (86.98%) and the lowest in analog rice sample E (68.76%) (Table 2). According to Priska *et al*. (2020), Nuabosi cassava has carbohydrate levels of 80–90%. Thus, the higher the composition of Nuabosi cassava, the higher the carbohydrate content in the produced analog rice.

3.1.6. Amylose Content

Table 2 shows the higher the addition of red kidney bean flour, the greater the amylose content of the resulting analog rice. Punia *et al*. (2020) reported that red beans contain a relatively high amylose content compared to other types of beans. Amylose content affects the physical quality and digestibility of analog rice. According to Handayani *et al*., 2017), the amylose content determines the texture of the cooked rice, including its dryness, softness, rate of hardening, and stickiness. The higher the amylose content in the rice, the firmer the cooked rice will be, and conversely, the lower the amylose content, the softer and stickier the cooked rice will be. Amylose is a polysaccharide that has a straight, unbranched chain structure, with a low molecular weight (Lal *et al*., 2021). Such molecular structure makes amylose difficult to digest. The higher the amylose content in rice, the lower the glycemic index (GI) value. Rice is classified into several groups based on its amylose content, namely low-amylose rice (<20%), intermediate-amylose rice (20–24%), and high-amylose rice (>25%) (Meullenet *et al*., 2000). Table 2 revealed a significant difference (p<0.05) in the amylose content of each formulation, with all analog rice samples producing intermediate amylose content. The rise in amylose levels is influenced by the increase in the composition of red kidney bean flour. According to Ratnawati *et al*. (2019), the amylose content of red kidney bean flour reached 20.14%.

3.1.7. Crude Fiber Content

The crude fiber content of various samples of analog rice made from Nuabosi cassavas and Inerie red kidney beans ranged from 9.29–29.39% (Table 2). Samples E and A showed the highest and lowest crude fiber content, respectively. The high fiber content in the analog rice samples is suspected to be due to the addition of red kidney bean flour. Ratnawati *et al*. (2019) reported that the total fiber content of red kidney bean flour reached 23.80%, whereas that of cassava flour was 6.84% (Hidayat *et al*., 2017). High levels of dietary fiber have a role in maintaining a healthy digestive tract (Ratnawati *et al*., 2019).

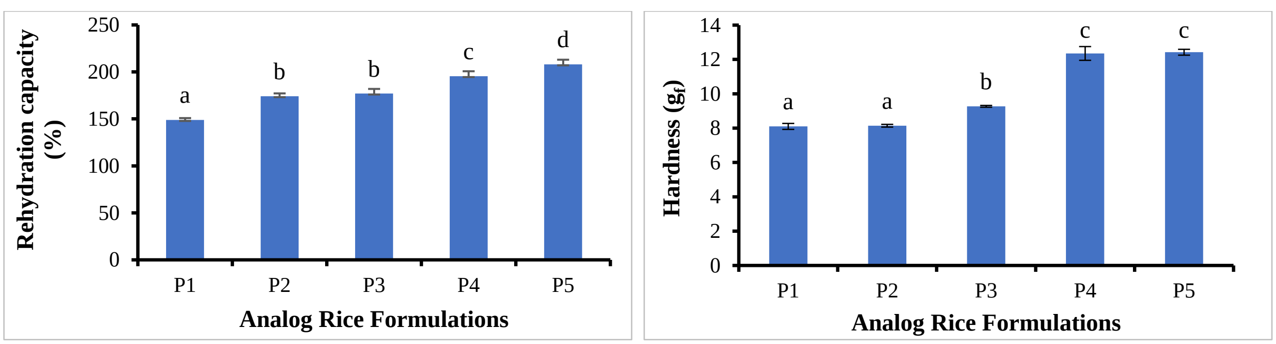
3.2. Physical Characteristics of Analog Rice

3.2.1. Rehydration Capacity of Analog Rice

The composition of Nuabosi cassava flour and Inerie red kidney bean flour had a significant effect (p<0.05) on the physical characteristics of the produced analog rice, as seen in its rehydration capacity and hardness value. The values of analog rice's rehydration capacity which range from 148.84% (A) to 208.00% (E) as well as its texture (hardness) values, which range from 7.23 g (E) to 12.08 g (A) (Figure 2). The rehydration capacity of analog rice is influenced by the nature of the raw materials used. In this study, an increasing trend in rehydration capacity is observed as the composition of Nuabosi cassava flour decreases and the Inerie red kidney bean increases. In addition, the amylose content in analog rice affects its rehydration rate. The higher the amylose content, the higher the rehydration capacity. Amylose is composed of hydroxyl groups with a linear and more open structure, allowing it to form hydrogen bonds with water and enabling higher and more efficient water absorption (Yuwono *et al*., 2015). When the amylose content in analog rice increases, more amylose molecules are able to absorb water, thereby improving the rehydration capacity.

The high protein content of analog rice also contributes to its rehydration capacity. Mohajan *et al*. (2018) stated that proteins can bind to water molecules through hydrogen bonds, which ultimately increases the rehydration capacity. Based on the measurement results, the highest hardness values of analog rice samples were found in samples D and E, namely 12.35 g_f and 12.42 g_f, both of which were not significantly different from each other but differed substantially from other analog rice samples. Similar to its rehydration capacity, the hardness level of analog rice is also influenced by its amylose content. This is as stated by Li *et al*. (2016), that the amylose content is directly proportional to the hardness value of analog rice.

The rehydration capacity parameter is intended to be used as a reference to assess the water absorption ability during cooking, control product quality, and determine the cooking time and process (Faturochman *et al*., 2022; Handayani, 2017; Jariyah & Vestra, 2023). The rehydration process in analog rice are key to producing a high-quality product with texture and properties resembling those of real rice. It can be said that a high rehydration capacity in analog rice is considered better because it demonstrates the rice's ability to absorb water effectively, thus resembling the texture and properties of real rice.



(a) (b)

Figure 2. Characteristic of analog rice from Nuabosi cassavas and Inerie red kidney beans: (a) Rehydration capacity, (b) Hardness. The graph values show mean ± SD; different letters indicate significant differences (p<0.05) based on Duncan's test.

3.2.2. Morphological Appearance

As shown in Figure 3, there was a difference in the morphological structure of the starch granules in the analog rice. Figure 3A showed a more homogeneous surface, which appeared slightly denser compared to the treatments with Inerie red kidney beans flour (3B–E), which exhibited irregular pores and membranes on the surface due to the addition of Inerie red kidney beans flour (see circle and arrow signs).

The starch content in red beans reached 43% (Astuti *et al*., 2019). The higher the percentage of red kidney beans flour was added, it was suspected to have affected the formation of pores and membranes on the surface. The high porosity increased the water absorption capacity, thereby increasing the rehydration time (Handayani *et al*., 2017).

3.3. Total Phenolics and Antioxidant Activity

To analyze its ability as a functional food, analog rice from Nuabosi cassavas and Inerie red kidney beans was tested for its total phenolic content (TPC) and antioxidant activity (AO) activity (Table 3). The composition of Nuabosi cassava flour and Inerie red kidney bean flour had a significant effect (p<0.05) on the TPC and antioxidant activity of

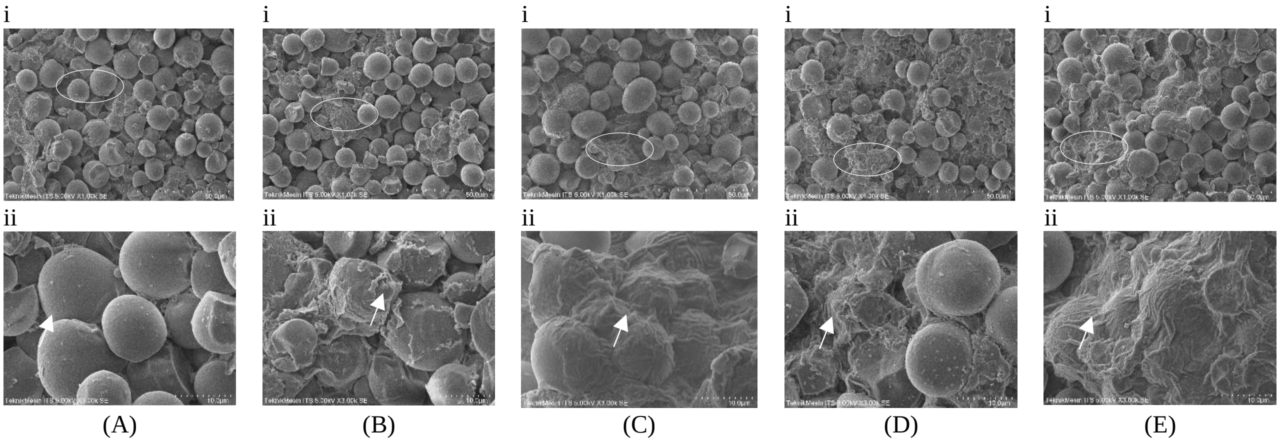


Figure 3. Results of the SEM analyses of analog rice from various comparison variations of Nuabosi cassavas and Inerie Red kidney beans, with magnifications of 1000x (i) and 3000x (ii); A=98:0; B=88:10; C=83:15; D=78:20; E=73:25

the produced analog rice. In this study, the highest TPC was found in analog rice samples D and E (c=c), i.e., 28.40 mg GAE/100 g and 28.10 mg GAE/100 g, respectively (Table 3). TPC contributes to the ability of analog rice to counteract DPPH free radical compounds. Furthermore, the AO activity value shows a rising trend as the TPC value increases. The total phenolic content of analog rice contributes to the electron transfer system from H atoms to free radical compounds. In this study, analog rice samples D and E (c=c) have the highest AO activity. The raw materials and production methods used are believed to affect the bioactivity of analog rice. Adefegha *et al.* (2021) explained that cassava flour processed by drying in the sun has a TPC of up to 64 mg/g. In this study, there was an increase in TPC and AO activity with the addition of Inerie red kidney bean flour. Carbas *et al.* (2020) found that the phenolic content of red kidney bean flour itself ranged from 3.37–3.84 mg GAE/g. A similar trend was also reported by Ramírez-Jiménez *et al.* (2018), that the addition of red bean flour can increase the bioactive components and antioxidant activity of snack bar foods. The granulation method used in the production of analog rice is suspected to be able to minimize the degradation of bioactive components due to the high temperature of the extruder machine (Hidayat *et al.*, 2017).

Table 3. Total phenolic content and antioxidant activity of analog rice from Nuabosi cassavas and Inerie red kidney beans

Parameters	Treatments				
	A (98%:0%)	**B (88%:10%)**	**C (83%:15%)**	**D (78%:20%)**	**E (73%:25%)**
TPC (mg GAE/100g)	25.25 ± 0.32[a]	26.92 ± 1.17[b]	26.05 ± 0.3[ab]	28.40 ± 0.32[c]	28.10 ± 0.2[c]
AO (%)	71.18 ± 0.63[a]	72.26 ± 1.12[a]	78.87 ± 0.65[b]	83.15 ± 1.06[c]	84.08 ± 1.52[c]

Note: The mean value ± SD followed by different letters in the same row indicates a significant difference (p<0.05) based on Duncan's test.

3.4. Sensory Evaluation

Figure 4 displays the average sensory scores of analog rice samples with various compositions of Nuabosi cassava flour and Inerie red kidney bean flour. The scores for aroma and texture did not differ significantly (p>0.05) among all samples; the panelists mostly enjoyed the aroma and texture of the analog rice samples. Meanwhile, the score for taste showed a significant difference (p<0.05). The panelists may not have liked the taste of the produced analog rice because of the bitter taste of the red kidney beans used (Nugraheni *et al*., 2020). This can be seen in the analog rice sample E with the highest red kidney bean composition, which was less liked by the panelists in terms of taste. Conversely, for samples A–D, the panelists have recognized the taste and even started to enjoy it. As for the overall qualities of the analog rice samples, the panelists mostly chose neutral and started to like (3–4) the analog rice produced. However, sample E received a significantly lower overall score from the panelists, compared to the other samples. Analog rice with the highest ratio of red kidney bean flour (25%) was less preferred by the panelists because it was associated with a bitter taste. According to Nugraheni *et al.* (2020), a bitter taste was often found in food products

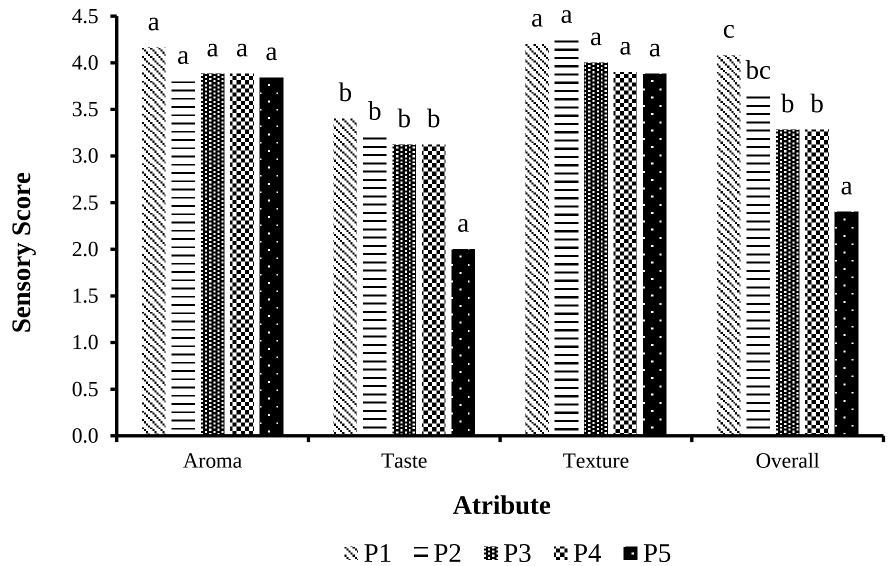


Figure 4. Sensory analysis results of analog rice from Nuabosi cassavas and Inerie red kidney beans. Different letters between bars on each attribute indicate significant differences ($p<0.05$) based on Duncan's test.

that combined legumes, one of which was red kidney beans. This was associated with the influence of tannin compounds in legumes.

4. CONCLUSION

The results of this study indicate the D sample with a ratio of Nuabosi cassava flour and Inerie red kidney bean flour of 78:20 was assessed as having relatively good characteristics statistically, with a moisture content of 13.18%, ash content of 2.86%, fat content of 4.55%, protein content of 5.89%, carbohydrate content of 73.51%, crude fiber content of 26.08%, amylose content of 28.17%, rehydration capacity of 195%, hardness value of 12.35 g, total phenolic content of 28.40 mg GAE/100 g, and DPPH antioxidant activity of 83.15%. Furthermore, the results of the sensory analysis show that most panelists had started to like the aroma, taste, and texture of analog rice produced from 78% cassava flour and 20% red kidney bean flour. The analog rice produced has functional properties and can be developed as a local-based alternative for rice.

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