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Antioxidants and Fiber Rice Analog Based on Composite Flour (Moringa, Purple Sweet Potato, and Cassava) as Local Food Diversification

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Abstract: This study explores the development of analog rice from composite flours of moringa, purple sweet potato, and cassava to diversify local food and enhance nutritional value. The purpose of this study was to identify antioxidants and rice fiber analogue composites from moringa, purple sweet potato and cassava. The experimental design used was a Completely Randomized Design (CRD) with 1 factor of flour type (A) with a combination of 3 levels of treatment, namely: A1 = Moringa flour 150g, purple sweet potato flour 100g and cassava flour 50g; A2 = Moringa flour 125g, purple sweet potato flour 75g and cassava flour 100g; A3 = Moringa flour 100g, purple sweet potato flour 125g and cassava flour 125g; A4 = Moringa flour 75g, purple sweet potato flour 100g and cassava flour 150g. Using a completely randomized design, four formulations with varying ratios of the three flours were evaluated for fiber content and antioxidant activity. The results revealed significant differences ($p<0.05$) in both attributes across formulations. The highest fiber content (3.55%) was observed in the formulation with 150 g purple sweet potato flour, 100 g moringa flour, and 50 g cassava flour, while the highest antioxidant activity (11.80%) was achieved using 100 g each of moringa and cassava flours and 50 g purple sweet potato flour. These findings underscore the potential of composite flours to produce analog rice with enhanced nutritional benefits, contributing to sustainable food security and local food innovation.

Keywords: Analogue rice, Antioxidant, Composite, Fiber, Lokal food.

Introduction

Analog rice is an innovation in the food world that functions as a substitute for rice made from alternative raw materials other than rice (Bahlawan *et al.*, 2023; Chaturvedi & Manickavasagan, 2024). Developing analogue rice is essential to creating more sustainable food and meeting people's nutritional needs, especially to face future food security challenges (Fanzo & Miachon, 2023). One promising approach is using local ingredients rich in nutritional content, such as moringa flour, purple sweet potato flour, and cassava flour, which are known to have great potential in increasing nutritional value and food availability.

Moringa flour (*Moringa oleifera*) has extraordinary nutritional content, such as high protein, vitamins, minerals and antioxidants (Devi *et al.*, 2023). Moringa is known to increase endurance and has many health benefits, so its use in analogue rice can improve the

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nutritional quality of the product (Hia, 2022). Apart from that, Moringa flour is also relatively easy to obtain, especially in tropical areas like Indonesia, which makes it a potential ingredient to be developed as the main component in making analog rice (Wahyuni & Nugroho, 2014).

Purple sweet potato flour (*Ipomoea batatas* L) also offers excellent potential as a raw material for rice analogs (Mustapa *et al*., 2021). Purple sweet potatoes are rich in Fiber, anthocyanins, and various vitamins and minerals (Farida *et al*., 2024). The anthocyanin content in purple sweet potatoes is an antioxidant, which can help fight free radicals and maintain body health (Husna *et al*., 2013). The use of purple sweet potato flour as an additional ingredient in analog rice can provide higher nutritional benefits and improve the taste and visual appearance of analog rice with an attractive purple color (Bashor *et al*., 2023).

Cassava flour (*Manihot esculenta*) is a raw material that is very easy to obtain and has long been used in various processed food products (Pasca *et al*., 2022). Cassava contains high starch, which makes it very suitable as a substitute for rice (Saraswati *et al*., 2022). Apart from that, cassava contains carbohydrates, which are a good source of energy (Yudha *et al*., 2023). Cassava is also known to have good resistance to less fertile soil conditions (Immanuel *et al*., 2024), making it a reliable material for developing analog rice that is more affordable and readily available.

The use of rice analogs based on composite flours, especially those containing Moringa, purple sweet potato (*Ipomoea batatas*), and cassava, has been shown in recent studies to improve the nutritional profile of food products by raising dietary fiber content and antioxidant activity. Due to its high anthocyanin content, purple sweet potatoes have strong antioxidant qualities that support several health advantages, including possible anti-diabetic and anti-cancer actions (Hu *et al*., 2016; Rahman & Nurdin, 2023; Sembiring *et al*., 2021).

Additionally, the prebiotic properties of sweet potato dietary fiber help to improve gut health by selectively boosting good bacteria in the intestine and improving digestive health in general (Bordunova *et al*., 2023; Waidyarathna *et al*., 2021). In the field of functional foods, it has been demonstrated that using purple sweet potato in composite flour enhances the texture and sensory qualities of baked goods and snacks in addition to adding nutritional fiber (Safira *et al*., 2024; Singh & BK, 2015).

Additionally, new research indicates that adding these useful chemicals to staple foods can help address nutritional deficiencies that are common in a variety of populations, especially in developing nations where access to a wide variety of foods may be restricted (Kamal *et al*., 2013; Palupi *et al*., 2024). In addition to improving the nutritional profile of conventional foods, the creative use of purple sweet potato flour provides a route for the creation of novel functional foods with health-promoting qualities (Trancoso-Reyes *et al*., 2016; Mujianto *et al*., 2024).

Making analog rice based on moringa flour, purple sweet potato flour, and cassava flour can solve the food security problem while increasing society's nutritional value. Using local ingredients can also help reduce dependence on rice imports and create new economic opportunities in the agricultural sector. By utilizing the potential of abundantly available raw materials, the development of analog rice can majorly contribute to creating healthy, nutritious, and sustainable food for the future.

Method

The experimental design used was a Completely Randomized Design (CRD) with 1 factor of flour type (A) with a combination of 3 levels of treatment, namely:
A1 = Moringa flour 150g, purple sweet potato flour 100g and cassava flour 50g
A2 = Moringa flour 125g, purple sweet potato flour 75g and cassava flour 100g
A3 = Moringa flour 100g, purple sweet potato flour 125g and cassava flour 125g
A4 = Moringa flour 75g, purple sweet potato flour 100g and cassava flour 150g

Thus, there were four treatment combinations with three repetitions and 16 experimental units. The analog rice formulation refers to research Winarti *et al.* (2018) with modifications.

Research Procedures

Making analog rice according to the method Marjan (2021) consists of several stages: preparation of raw materials, mixing, steaming, extrusion, and drying. The raw material is prepared by weighing the ingredients according to the formulation. The mixing process is carried out by mixing dry raw materials and 17% water until the mixture is homogeneous. Next, the steaming process is carried out for 30 minutes. After that, the extrusion process is carried out using an extruder. During the extrusion process, the dough will experience shedding and forming. Forming is done through a mold at the end of the extruder. Then the resulting extruded rice is dried using an oven at 60^{o}C for 3 hours to reduce the water content of the analog rice to <14%, which is expected to extend the product's shelf life. After that, the analog rice is packaged in tight and vacuum packaging. The following is a flow chart for making moringa composite analog rice, purple sweet potato and cassava in Figure 1.

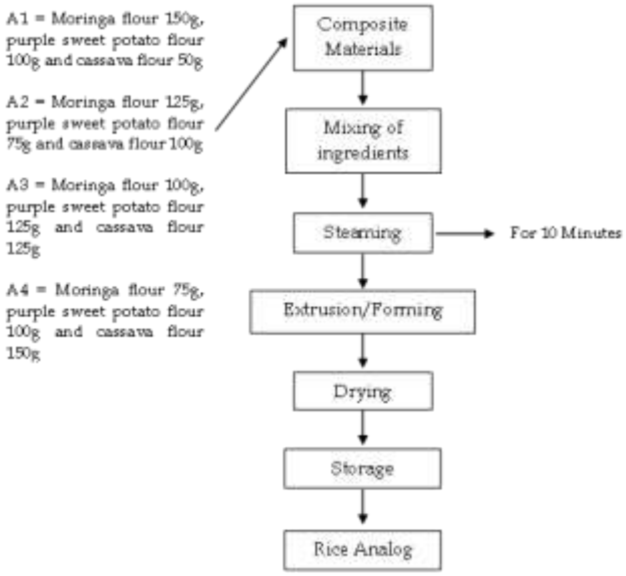

Figure 1. Making Moringa Composite Analog Rice, Purple Sweet Potato and Cassava

Fiber

Samples in fine form were weighed at 1 gram and put into an Erlenmeyer. After that, 100 mL of 0.325 N sulfuric acid was added. Then, the sample was refluxed for 30 minutes. Next, the sample was filtered using Whatman filter paper, and distilled water was added to the filtered solution until the sample reached a neutral pH condition. After that, NaOH was added to the sample. 1.25 N as much as 50 mL and refluxed again for 30 minutes. Next, the refluxed sample is cooled and filtered again using the Whatman filter paper of known weight. Then, the residue left behind was washed sequentially with 25 mL of distilled water, 20 mL of 95% ethanol, and 25 mL of 10% K2SO4. Afterwards, the residue was washed in filter paper, dried in an oven at 105oC for 2 hours, and left in a desiccator for 15 minutes (AOAC, 2005). The fiber content value is calculated using Formula 1.

$$\%\ \text{Fiber} = \frac{Dry\ Residue\ Weight\ (g)}{Sample\ Weight\ (g)}\ x\ 100\% \quad (1)$$

Antioxidant

Chemically speaking, antioxidants are substances that donate electrons, and physiologically, they are substances that can counteract the harmful effects of oxidants in the body, such as harm to essential components of bodily cells (Winarsi, 2007). Maintaining the integrity and phenol function of lipid membranes, cell proteins, and nucleic acids, as well as regulating signal transduction and gene expression in immune cells, all depend on the body's immune system functioning, which makes the balance between oxidants and antioxidants crucial (Ariyanti & Aditya, 2016).

To determine the activity of antioxidants in sweet and spicy watermelon sprinkles, the DPPH method was modified by Amin *et al.* (2015). The following is the antioxidant testing process using the DPPH method. To get a solution concentration of 1000 ppm, the sample extract was weighed to 10 mg, transferred to a 10 ml measuring flask, and then tested using an ethanol solvent. After that, a series of dilutions was performed to obtain solutions at 20, 40, 60, 80, and 100 ppm. Three millilitres of 50μM DPPH solution (1.97 mg/100 ml methanol) were added to the prepared solution, which had been pipetted up to one millilitre. After homogenizing the mixture, it was placed in a dark area for half an hour. A wavelength of 517 nm was then used to measure the absorbance. Additionally, the DPPH solution was tested. The following formula was utilized to calculate the percentage inhibition based on the acquired absorbance value:

$$\%\ Inhibition = \frac{Abs.DPPH - Abs.Sample}{Abs.\ DPPH}\ X\ 100\% \quad (2)$$

Data Analysis

The data obtained will be analysed using Analysis of Variance (ANOVA) at a significant level of 5%. If there is a fundamental difference, it will continue with a further Honest Significant Difference (BNJ) test at the same significance level.

Results and Discussion

Fiber

A plant material known as dietary fiber is indigestible by the digestive enzymes of humans. Dietary fibre components include hemicellulose, cellulose, lignin, oligosaccharides, pectin, gum, and wax coating. Compared to crude fiber, dietary fiber has a different definition. According to Ratnaduhita (2019), A plant residue left over after multiple extractions using solvents, alkali, and diluted acid, is known as crude fiber.

The only indigestible components of crude fiber are cellulose, hemicellulose, and lignin. According to Yurni & Sinaga (2017), The value of crude fibre is usually lower when compared to dietary fibre; in fact, only approximately one-fifth of the total dietary fibre. Analysis of crude fibre content is the weight of the sample lost after aching. The high crude fiber content can slow down the process of nutrient digestion, providing a more prolonged feeling of fullness and slowing down the appearance of blood glucose (Noviasari *et al.*, 2013).

The variance analysis showed that the treatment of variations in analogue rice formulations consisting of moringa flour, cassava flour and purple sweet potato flour had a significant effect (p<0.05) on the fibre produced. This indicates a significant difference in response to analogue rice fiber due to the different formulations used.

Research on analogue rice based on a composite of moringa flour, purple sweet potato flour, and cassava flour showed significant results in fiber in various formulations. Sample A2 (100 g moringa flour, 150 g purple sweet potato flour, and 50 g cassava flour) produced the highest fiber at 3.55%, which was significantly different (p<0.05) compared to the other treatments. Sample A1 (100 g moringa flour, 100 g purple sweet potato flour, and 100 g cassava flour) showed the second highest fibre at 2.77%, followed by A3 (100 g moringa flour, 50 g purple sweet potato flour, and 100 g cassava flour) with fibre of 2.67%. The lowest fiber was found in sample A4 (50 g moringa flour, 100 g purple sweet potato flour, and 150 g cassava flour) at 2.64%. These results indicate that the proportion of purple sweet potato flour and cassava flour significantly influences fiber in analogue rice formulations, with moringa flour as the primary fiber source. The following fiber values (%) in each treatment are shown in Figure 2.

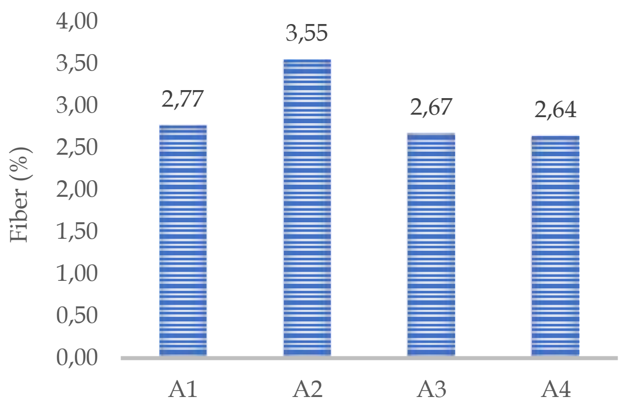

Figure 2. Analogous Rice Fiber Content Values with Different Formulations of Purple Sweet Potato Flour, Moringa Flour and Cassava Flour.

The source of fiber from the analogue rice produced is thought to be obtained from cassava flour. Optimal administration of cassava flour provided high fiber value in this study. This is consistent with research Hasbullah *et al*. (2023), Adding mocap flour or cassava flour can increase crude fibre compared to modified suweg flour.

Moringa and purple sweet potatoes work together to produce the appropriate flavor profile and boost the product's nutritional content. The nutrient value is enhanced by fortification with fiber from sweet potatoes and antioxidants from moringa, making this analog rice a nutritious substitute for those attempting to cut back on their rice intake (Budijanto *et al*., 2018).

Antioxidant

The variance analysis showed that treatment with variations in analog rice formulations consisting of moringa flour, cassava flour, and purple sweet potato flour had a significant effect (p < 0.05) on the antioxidant activity produced. This indicates a significant difference in response to the antioxidant activity of analog rice due to the different formulations used. The following antioxidant activity values (%) in each treatment are shown in Figure 3.

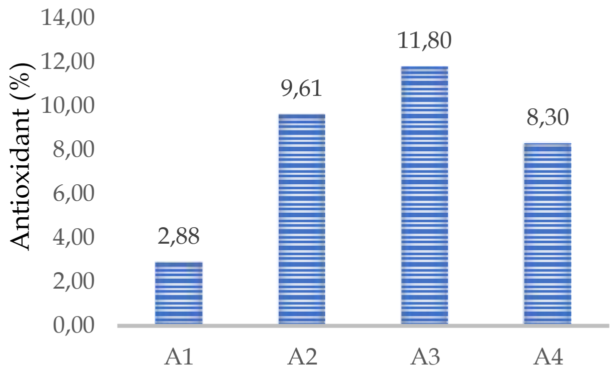

Figure 3. Antioxidant content values of analogous rice with different formulations of purple sweet potato flour, moringa flour and cassava flour.

Research on analogue rice based on a composite of moringa flour, purple sweet potato flour, and cassava flour showed significant results in antioxidant activity in various formulations. Sample A3 (100 g moringa flour, 50 g purple sweet potato flour, and 100 g cassava flour) produced the highest antioxidant activity of 11.80%, which was significantly different (p<0.05) compared to other treatments. Sample A2 (100 g moringa flour, 150 g purple sweet potato flour, and 50 g cassava flour) showed the second highest antioxidant activity of 9.61%, followed by A4 (50 g moringa flour, 100 g purple sweet potato flour, and 150 g cassava flour) with antioxidant activity of 8.30%. The lowest antioxidant activity was found in sample A1 (100 g moringa flour, 100 g purple sweet potato flour, and 100 g cassava flour) at 2.88%. These results indicate that the proportion of purple sweet potato flour and cassava flour has a significant influence on antioxidant activity in analog rice formulations, with the contribution of moringa flour as the primary antioxidant source (Khor *et al*., 2018; Kusmardika, 2020; Satriyani, 2021).

Research shows that moringa leaves, which are rich in antioxidants, can be used to improve the health function of analog rice, especially for people with diabetes mellitus (Nugraha *et al*., 2021)

Conclusion

Based on the findings of this study, it can be concluded that analog rice formulated from moringa flour, purple sweet potato flour, and cassava flour exhibits a crude fiber content ranging from 2.64% to 3.55% and an antioxidant content between 2.88% and 11.80%. These results suggest that the developed analog rice possesses potential nutritional benefits, particularly in terms of dietary fiber and antioxidant properties, which could contribute to its functional food applications. Further research is recommended to explore its sensory acceptability, shelf stability, and potential health benefits in greater detail.

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Author Contributions
Each author has contributed significantly to the completion of this work.

Conflicts of Interest
There are no conflicts of interest, according to the author.

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