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Evaluation of physicochemical properties and functional potential of analog rice based on commercial flours of porang tuber and gembili as an alternative carbohydrate food source

Evaluasi sifat fisikokimia dan potensi fungsional beras analog berbasis tepung komersil umbi porang dan gembili sebagai alternatif pangan sumber karbohidrat

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Abstract

Indonesia is one of the countries that produces porang and gembili tubers that can be processed into value-added food products. One innovation that can be developed is the analog rice made from these two tubers. Porang and gembili tubers are known to contain bioactive compounds and dietary fiber that provide functional benefits, such as lowering blood glucose levels, improving lipid profiles, and improving digestive tract health. This study aimed to evaluate the physical and proximate qualities of three analog rice formulations using commercial porang and gembili flours. The experimental design used was a Completely Randomized Design (CRD) with two replications, conducted from August to December 2024 at the Technopark Laboratory (Faculty of Agricultural Technology) and Nutrition Analysis Laboratory (Department of Community Nutrition, FEMA IPB). The formulations had porang and gembili ratios of F1 (75:25), F2 (50:50), and F3 (25:75). Data were analyzed using One-Way ANOVA preceded by variance homogeneity testing, followed by DMRT multiple range test. The results showed that cooking time and bulk density differed significantly between F1, F2, and F3. The expansion ratio, degree of breakage, and hardness differed significantly among F3, F1, and F2. F3 exhibited the highest brightness (L*) value. Proximate analysis revealed significant differences in ash, moisture, protein, fat, and carbohydrate contents among all formulations. The F3 formulation, which had a higher proportion of gembili, demonstrated the greatest potential as a staple carbohydrate source. However, further sensory and consumer acceptability improvements are needed.

Keywords: Analog rice, food diversification, gembili flour, porang flour, physicochemical

Abstrak

Indonesia merupakan salah satu negara penghasil umbi porang dan gembili yang berpotensi diolah menjadi produk pangan bernilai tambah. Salah satu inovasi yang dapat dikembangkan adalah beras analog berbahan dasar kedua umbi tersebut. Umbi porang dan gembili diketahui mengandung senyawa bioaktif dan serat pangan yang memberikan manfaat fungsional, seperti menurunkan kadar glukosa darah, memperbaiki profil lipid, dan menyehatkan saluran pencernaan. Penelitian ini bertujuan untuk mengevaluasi mutu fisik dan proksimat dari tiga formulasi beras analog menggunakan tepung porang dan gembili komersial. Rancangan percobaan yang digunakan adalah Rancangan Acak Lengkap (RAL) dengan dua kali ulangan, dilaksanakan pada bulan Agustus sampai dengan Desember 2024 di Laboratorium Technopark (Fakultas Teknologi Pertanian) dan Laboratorium Analisis Gizi (Departemen Gizi Masyarakat, FEMA IPB). Formulasi yang dibuat adalah F1 (75:25), F2 (50:50), dan F3 (25:75) dengan perbandingan porang dan gembili. Data dianalisis menggunakan ANOVA Satu Arah, didahului dengan uji homogenitas varians dan diikuti oleh DMRT. Hasil analisis sifat fisik menunjukkan bahwa parameter waktu pemasakan dan densitas kamba berbeda signifikan antara formula F1 dengan F2 dan F3. Sementara itu, parameter rasio pengembangan, degree of breakage, dan kekerasan menunjukkan perbedaan signifikan antara F3 dengan F1 dan F2. Sama halnya paramaeter warna kecerahan (L*) bahwa F3 memiliki indikator paling terang. Analisis proksimat terhadap kadar abu, air, protein, lemak, dan karbohidrat menunjukkan perbedaan signifikan di antara ketiga formulasi. Formulasi F3, dengan proporsi gembili yang lebih tinggi, menunjukkan potensi terbesar sebagai sumber pokok karbohidrat. Namun, diperlukan peningkatan sensori dan penerimaan konsumen lebih lanjut.

Kata Kunci: Beras analog, diversifikasi pangan, tepung gembili, fisikokimia, tepung porang

Introduction

Quality, nutrition, and balanced food are basic requirements that must be met to realize quality human resources. Food insecurity can worsen the quality of food and health; therefore, it is necessary to utilize food and optimize carbohydrate sources other than rice as a staple food in Indonesia (Fikha, 2023). Obesity is experiencing an increasing trend, with prevalence of 10,5% and 21,8% in 2013 and 2018, respectively (WHO, 2024). It is a risk factor for non-communicable diseases such as cardiovascular disease, type 2 diabetes mellitus, cancer, and musculoskeletal disorders (Kementerian Kesehatan RI, 2023).

Diversification is an effort to anticipate a food crisis by realizing food independence. The food crisis in Indonesia can be anticipated through food diversification and the development of local food products (Dewi & Ginting, 2012). One step in promoting food diversification is to improve food-processing technology that aligns production policies with consumption patterns (Hardono, 2016). Food insecurity causes the consumption of low-quality energy-dense foods. This is the basis for food insecurity as a cause of obesity (Fikha, 2023). The occurrence of food insecurity is associated with obesity, as indicated by the body mass index (BMI)(Fikha, 2023; Morales & Berkowitz, 2016; Nguyen et al., 2015; Sirotin et al., 2014; Unicef, 2023). Food insecurity is one of the multifactors that causes obesity (López-Cepero et al., 2020). Food insecurity conditions tend to have low purchasing power and, thus, the choice of low-quality food. This food contains excess carbohydrates and is low in fiber, vitamins, and minerals (Faza et al., 2023). Low food quality is a major factor in increasing obesity in food insecure environments and in a lack of food diversification (Setyaningsih et al., 2024). Fulfillment and improvement of food quality is achieved through food diversification, and is one of the efforts to realize food security and improve community nutrition. In addition, efforts have been made to reduce dependence on staple foods in the form of rice (BRIN, 2024).

In addition, rice production in Indonesia has decreased and rice imports have increased (BPS, 2019, 2023). This is a major issue in terms of fulfilling staple foods and the impact of non-communicable diseases caused by nutritional status problems in the form of obesity. Processing technology in the form of extrusion is used to produce analog rice from non-rice food sources as an alternative staple food that can meet the needs of rice in Indonesia (Budi, 2013; Budijanto, 2017). Analog rice is a solution to food diversification programs and the current public health problems (Saloko et al., 2020).

Porang tubers (*Amorphophallus muelleri*) are tuber plants that contain a lot of glucomannan fiber. Glucomannan is a soluble fiber that forms a gel mimicking the characteristics of fat (Latief et al., 2023). The yield of glucomannan isolated directly from fresh porang tubers reached 50,0%–65,2%, with a purity of 77–91%, depending on the method used (Yanuriati et al., 2017). Additional dietary fibers, such as inulin, pectin, seaweed gum, and β-glucan, can prevent and even treat obesity (Chambers et al. 2019, Howarth et al. 2001, Tremblay et al. 2020). The bioactive compound glucomannan in porang includes water-soluble fibers, which can improve health by lowering plasma cholesterol levels, increasing carbohydrate metabolism, and increasing bowel movements (Du et al., 2021). This makes it possible for this type of bioactive compound to be applied in a wide range of fields such as functional foods, therapeutic interventions, and nutraceuticals (Jain et al., 2025). Further research is needed to explain the mechanism underlying the anti-obesity effect of administering porang tubers and increasing lipid metabolism by administering porang-based foods (Aoe, 2015).

Gembili tuber (*Dioscorea esculenta*) has a distinctive taste with a texture resembling sweet potato and the flesh of this tuber is pure white (Prabowo et al. 2014; Utami et al. 2013). Every 100 grams of yam tubers with an edible weight of 85%, contains 131 kcal of energy, 1,1 g of protein, 0,2 g of fat, 31,3 g of carbohydrates, 1,1 g of fiber (Kemenkes RI, 2018). The nutritional content of yam tubers varies depending on species and variety. Yam tubers are a source of carbohydrates and are used as staple food. Yam tubers are known to have a high carbohydrate content of 22,5–31,2%, which is even higher than that of rice. This carbohydrate content demonstrates the potential of yam tubers as alternative energy sources to replace rice. In addition to being a source of energy, yam tubers have added value from a functional perspective because they contain various bioactive compounds, such as water-soluble polysaccharides (PLA), diosgenin, and disocorin, which are known to have beneficial effects on body health (Prabowo et al., 2014). These two types of tubers are optimally utilized and processed into products that are beneficial for health (Yofananda & Estiasih, 2016). Analog rice substitution has been widely modified to obtain the best formula for solving problems related to blood sugar, blood fat, and nutritional status (Fauziyah et al., 2017).

Therefore, this study aimed to evaluate the physical and proximate qualities of three analog rice formulations made from porang and gembili tubers. This is because there have been no studies comparing the physicochemical characteristics of analog rice made from a combination of porang and gembili in three formulations.

Methods

A Completely Randomized Design (CRD) was used in this experimental study, which included three treatments with two replications. The treatment given in making analog rice used a comparison of porang tubers and gembili tubers with the formulation F1 (25:75), F2 (50:50), and F3 (75:25). This study was conducted between August and December 2024. Product manufacturing and physical quality analyses in the form of cooking time, development ratio, and degree of breakage were performed at the Fateta IPB Technopark Laboratory. Physical analyses of kamba density, hardness, and color were performed at the FEMA IPB Nutrition Food Experiment Laboratory. Proximate analysis in the form of ash, water, protein, fat, and carbohydrates was performed at the Nutrient Analysis Laboratory of the Department of Community Nutrition, FEMA IPB.

The materials needed in the first stage of making analog rice are commercial flour of porang and gembili tubers obtained from an organic shop in Sleman, Special Region of Yogyakarta, and food grade Glycerol Monostearate (GMS) obtained from a research material shop in Tangerang, Banten. The second stage involved testing the physical properties of the materials used as analog rice samples and plain water. The third stage involved testing water, ash, protein, fat, and carbohydrates, including distilled water, concentrated H2SO4, selenium, 40% NaOH, (H3BO3) 4%, Na2CO3, NH4SO4, MM:MB indicator, 0.1 N HCl, 25% HCl, and hexane solvent.

Preliminary research was conducted to determine the heating temperature used for rice extrusion to obtain the best temperature. The formulation consisted of three treatments (Table 1).

Table 1. Formulation of analog rice porang and gembili tubers

Treatment	Formula (%)	
	Porang	Gembili
F1	75	25
F2	50	50
F3	25	75

The first stage is the manufacture of analog rice with the main ingredients for making analog rice, namely porang flour and gembili, with the composition listed in Table 1. The other ingredients outside the composition were 2% GMS and 50% water. The temperature of the extruder barrel was maintained at 80°C through the shearing process, molding, and formation of premix granules to produce a shape that resembles rice grains after passing through the die process. The speed used was 50,1 Hz for the screw speed and 35,2 Hz for the cutter speed. The premixed granules were dried in an oven at

60°C for 3 h. The product-manufacturing experiment was performed twice.

The second stage was the analysis of physical properties, including cooking time, kamba density, expansion ratio, degree of breakage, hardness, and color. The cooking time was achieved by cooking analog rice with boiling water at a ratio of 1:1 using a rice cooker. When analog rice is placed in the rice cooker, the cooking duration is calculated from then on until it is cooked (Noviasari et al. 2013). Kamba density was measured using a 25 mL measuring cup filled with analog rice tapped on the table so that the rice grains could be packed evenly. Rice weight was measured by calculating the weight of rice divided by its volume (Sripinyowanich & Noomhorm, 2013). The level of damage to analog rice is known based on the percentage of broken grain weight to the total sample weight. Analog rice (10 g) was weighed randomly, broken, and intact grains were separated (Bui et al., 2018). The analog rice hardness was measured using the IMADA FRTS Texture Analyzer, which was performed 30 times on each sample, and then the average value was obtained (Budi et al., 2017a). Color analysis was performed with the Hunter L*, a*, and b* methods using a JZ-610 colorimeter. The tool was first calibrated, and then the sample was attached to the tool. Ensure that there are no light gaps, and the results appear after a few seconds. The larger the L* value, the brighter is the color of the analog rice. A positive a* value indicates a reddish nuance, negative a* value indicates a greenish nuance, positive b* value indicates a yellow nuance, and negative b* value indicates a blue nuance. The third stage, proximate analysis, consists of the analysis of ash, water, protein, fat, and carbohydrate content, which is carried out based on a previously described method (AOAC, 2005). The water content was determined by evaporating the water molecules with the sample weighed until the weight was constant. The evaporated water was calculated based on the difference in weight before and after drying. The analysis was performed by first drying the cup at 100–150 °C for 30 min and then cooling it using a desiccator. This stage was repeated at the same temperature, and cooling was performed using a desiccator until a relatively constant dry sample weight was obtained (AOAC 2005).

The principle of determining the water content by dry ashing is based on the principle of burning or ashing the material at high temperatures, and then weighing the remaining substances in the ashing process. First, the cup was oven dried. The cup was cooled in a desiccator and weighed. The samples were weighed and placed in a dried cup. The cup containing the sample was ashed in a furnace and burned until it became ash and a constant weight was obtained. The sample that was ashed was then cooled with a desiccator and weighed until a constant weight was achieved (AOAC, 2005).

Protein analysis is based on the principle that nitrogen compounds are converted to ammonium sulfate by sulfuric acid. Ammonium sulfate was decomposed using sodium hydroxide. Distillation and titration were also performed (AOAC, 2005).

The principle of the analysis was the extraction of free fat using non-polar solvents. Fat extraction was performed by placing lead in a Soxhlet apparatus and adding hexane to it. Fat was extracted by boiling, rinsing, and recovery. The hexane solution was distilled and the fat was extracted and dried in a drying oven. The fat extract and aluminum cup were cooled in a desiccator and weighed. The same steps were performed by drying in an oven at the same temperature until the weight was constant (AOAC, 2005).

The carbohydrate content was determined using the principle of 100% reduction in the percentage of ash, protein, and fat content (AOAC, 2005).

Data were entered into Microsoft Excel 2019 and statistically analyzed using SPSS 25.0. Data were analyzed using One-Way ANOVA followed by Duncan's multiple range test (DMRT) to identify differences between the three formulas. The data began by analyzing data homogenization and meeting the assumption of homogeneity of variance. The data consisted of three formulae, with two product manufacturing repetitions. The physical properties were measured and analyzed twice (duplicates) for each variable. The criteria for determining the best formula are based on a combination of significant physical and chemical parameters.

Result and Discussion

The physical properties of analog rice are one of the factors that influence its quality and acceptance by consumers. Analog rice usually has a grain size similar to that of paddy rice; however, the grain size can vary slightly depending on the raw materials and processing methods used. Some products have nonuniform grains that are larger or smaller than those of regular rice (Finirsa et al., 2022). Generally, the grains were elongated and slender. Table 2 presents the physical qualities of rice, which are analog to those of the porang and gembili tubers.

The cooking time of analog rice is influenced by the formulation used and the characteristics of the raw materials. Analog rice with a larger composition of porang tubers had a shorter cooking time. The addition of hydrocolloids affects the cooking duration, while GMS is used to improve the texture and reduce stickiness during the extrusion process and rice cooking (Damat et al., 2020; Kusnandar et al., 2024). Other factors also influence gelatinization temperature and amylose content. The higher the gelatinization temperature of the raw material, the longer is the cooking time. This is because higher temperatures require longer times to achieve optimal starch gelatinization. Foods with amylose contents absorb less water and require longer cooking times (Kusnandar et al., 2017 2024; Kusnandar et al., 2015).

Analog rice with a larger porang tuber composition had the lowest kamba density, which was different from that of F2 and F3. The low kamba density indicates that analog rice is more porous. This porosity is important because it affects water absorption and rehydration time during cooking. The lower the kamba density is, the faster the product absorbs water and cooks during cooking. Low kamba density affects nutrient density of food products.

Products with a lower bulk density absorb less nutrients per volume than those with higher densities. The drying and processing processes contribute to the bulk density. Proper drying removes excess moisture, increases porosity, and reduces the overall bulk density (Aini et al., 2020; Diniyah et al., 2016; Kurniasari et al., 2020a; Ningtyastuti et al., 2023).

Table 2. Physical quality of analog rice porang and gembili tubers

Formula	Cooking Time	Density of Kamba	Development Ratio	Degree of Breakge	Hardness
F1	3,93±0,51[a]	0,53±0,00[a]	125,36±23,40[a]	11,16±1,16[a]	16,63±2,52[a]
F2	5,48±0,82[b]	0,54±0,00[b]	131,88±17,31[a]	5,83±1,72[a]	16,19±2,68[a]
F3	5,55±0,96[b]	0,58±0,00[b]	169,56±12,89[b]	0,68±0,34[b]	13,03±1,45[b]

Data are presented as the mean ± standard deviation. Superscript letters in the same column indicate no significant difference at the 5% level (p > 0.05) based on Duncan's multiple range test.

The highest expansion ratio was observed in F3, which was significantly different from those of F1 and F2. The expansion rate of analog rice is an important parameter that indicates the increase in the volume of analog rice during cooking. The amylose content of the raw material has a major effect on the expansion ratio. The higher the amylose content, the better the analog rice absorbs water and expands when cooked. This is because amylose can form a three-dimensional structure that stores water. The water absorption capacity is closely related to the expansion ratio. The addition of additional materials, such as carrageenan, water absorption capacity, stability of the starch structure during cooking, and expansion ratio can be increased. This shows that in the case of analog rice, the formulation and manufacturing technology have a major effect on the final result (Jariyah & Vestra, 2023; Rachma et al., 2023; Srihari et al., 2016; Yudanti & Waluyo, 2015).

Analog rice with the largest yam composition showed the best rice quality among the other two formulas. The higher amylose content in the analog rice formulation affected grain strength, thus reducing breakage during processing and storage. Increasing the extrusion temperature affected the hardness and strength of the grains, thus reducing damage. In addition, the addition of additional ingredients, such as carrageenan, helped increase the stability of the analog rice structure, thus reducing the level of damage during cooking and storage. The low level of damage in analog rice indicated that the product was more resistant to cooking and storage. The microstructure of the analog rice contributed to the degree of breakage, with a denser and well-bound structure having a lower level of damage than loose or poorly bound grains. Analog rice with a low degree of breakage tends to have better texture and fewer broken particles during cooking (Budi et al., 2017b; Kurniasari et al., 2020b, 2020a).

Table 3. Color analysis of analog rice porang and gembili

Formula	L*	a*	b*
F1	27,00±2,45^{a}	7,19±0,68^{a}	7,65±0,78^{a}
F2	28,61±1,25^{a}	8,04±0,43^{b}	9,30±0,61^{b}
F3	32,81±1,17^{b}	8,69±0,46^{b}	10,43±0,68^{c}

Data are presented as the mean ± standard deviation. Superscript letters in the same column indicate no significant difference at the 5% level (p > 0.05) based on Duncan's multiple range test.

The color index of analog rice is presented in Table 3, with a larger composition of gembili tubers giving a brighter rice color than the other two formulas. The color of analog rice is greatly influenced by the raw materials used. If porang and gembili tubers are exposed to air after being cut or processed, enzymatic browning occurs (Rahayu et al., 2023). The polyphenol oxidase (PPO) enzyme in tubers reacts with oxygen to produce dark-colored compounds. The drying method affects the color change at high temperatures or for longer periods of time, and the color changes to dark brown owing to the Maillard reaction or caramelization. The darken color of gembili flour is due to the oxidation of phenolic compounds into melanoidins (Rahayu et al., 2023). L* indicates the level of color brightness, with values ranging from 0 (black) to 100 (white). The higher the L* value, the brighter is the color of the analog rice. In all three formulas, F1 had a darker color, which can be caused by the Maillard reaction owing to the highest protein content in the formula. This is because of the reaction between the carbonyl groups of the amino acid and sugar. This pigment forms a brown polymer that contributes to its color (Murata, 2021). In addition, non-enzymatic browning reactions can occur through dehydration and sugar degradation processes, resulting in new, undesirable compounds due to changes in color, texture and taste (Kocadağlı & Gökmen, 2018) The a* notation refers to the composition of red and green. A positive value (+a) indicates red and a negative value (-a) indicates green. Analog rice, a* values with small values, can be ignored when evaluating color quality. The b* value indicates the composition of yellow and blue. A positive value (+b) indicates yellow, whereas a negative value (− b) indicates blue. The higher the b* value, the more yellow the analog rice.

Table 4. Nutritional composition and energy content of analog rice porang and gembili tubers

Formula	Nutritional Composition (%)					Energy
	Moisture	Ash	Fat	Protein	Carbohydrate	(kcal)
F1	8,14±0,32^{a}	8,39±0,58^{a}	1,57±0,07^{a}	11,98±0,05^{a}	69,90±0,24^{a}	341,65
F2	5,51±0,10^{b}	6,26±0,05^{b}	1,21±0,02^{b}	9,57±0,19^{b}	77,43±0,15^{b}	358,89
F3	6,30±0,11^{c}	5,23±0,05^{c}	1,33±0,02^{c}	8,78±0,12^{c}	78,35±0,19^{c}	360,49

The energy values were calculated using the Atwater system: (carbohydrate × 4) + (protein × 4) + (fat × 9).
Data are presented as the mean ± standard deviation. Superscript letters in the same column indicate no significant difference at the 5% level (p > 0.05) based on Duncan's multiple range test.

Figure 1. Analog rice of porang and gembili tubers (F1, F2, F3 from left to right)

The proximate results of the three formulas showed that they met the requirements of the Indonesian National Standard (Standar Nasional Indonesia or SNI), except for the fat content, which still exceeded the requirements for analog rice. This suggests that the basic ingredients of porang and gembili tubers contain low amounts of fat. The results of this study showed an increase in fat content compared to raw material products. The water content of porang tuber flour was higher than that of gembili tubers; the higher the gembili flour composition, the lower the water content of analog rice. This is similar to the ash, protein, and fat contents. Both tubers have a high carbohydrate content that resembles rice, namely 69,90 – 78,35%. In addition, the calories in the three formulas have almost the same content as rice, that is, 357 kcal (Kemenkes RI, 2020). The results of the proximate analysis showed that there were significant differences in the three formulas, which became the basis for determining the superior analog rice formula in terms of its nutritional content, thus providing greater benefits.

Optimal water content is very important for maintaining the quality of analog rice. If the water content is too high, the rice will be wet and not durable; if the water content is too low, the rice will be brittle and difficult to control during the processing process. The standard water content of analog rice is 10-14% which varies depending on the type of raw material and processing method (Handayani et al., 2022; Ratnaduhita et al., 2022). Ash content is an important indicator of the quality of analog rice, reflecting the amount of minerals and organic matter contained in the product. The formulation of raw materials and the manufacturing process allow for the control of the ash content according to the desired quality standards (Finirsa et al., 2022). Processing methods, such as heating and extrusion, also affect the ash content. The heating process changes the structure of starch and affects its interaction with other ingredients, thereby changing the ash content (Finirsa et al., 2022; Novikasari et al., 2023).

The fat content in analog rice is due to the use of GMS as an additional ingredient in the production of analog rice. GMS is an ester of glycerin and fatty acids; therefore, it naturally contains fat. Previous studies have shown that the higher the concentration of GMS, the higher is the fat content in the final product (Akbar et al., 2023). Similarly, in a study using GMS in noodle food products containing 1.18% fat, the addition of GMS directly contributed to an increase in the fat content of the final product (Damat et al., 2020).

The protein content in gembili tubers is higher than in porang tubers, namely 1,10 g/100 g, which has a significantly different effect on the three formulas (Sabda et al., 2019). Paddy rice contains 8,4 g/100 g of protein; therefore, analog rice in the three formulas contains higher protein, which has the potential to be a staple food source with a nutritional content similar to that of rice (Kemenkes RI, 2018).

Figure 2. Cooked analog rice

Analog rice with the same cooking method as regular rice, F1 requires an average cooking time of 3-4 minutes which is the fastest of the two. As shown in Figures 1 and 2, among the three formulas, F1, which had a higher composition of porang flour, had more regular grains. The largest expansion ratio and degree of breakage were observed in F3, which had the highest gembili flour composition. Similarly, after cooking, F3 contained larger rice grains than the other two formulas.

Conclusion

The analog rice of porang and gembili tubers has nutritional content according to the SNI, except for fat, which exceeds these requirements. Among the three formulas, F3 is the best based on the results of the physical and proximate analyses. This formula had a higher degree of breakage, hardness, and color value than the other two formulas. Based on the nutritional content, the water and ash contents were the lowest in F3. In addition, F3 contained the highest amount of carbohydrates as a staple food. F3 analog rice has the potential to be further developed as an alternative functional food to rice with high carbohydrate content and good physical quality, but further formulation is needed to reduce fat content and increase sensory acceptance.

Further research is recommended to use independently produced porang and gembili flours to better control the treatment and the presence of treatments to reduce oxalic acid levels in both tubers. The content of bioactive compounds in products made from porang and gembili tubers requires further analysis. High production of both tubers has the potential to be developed by the food industry because of the increasing market demand for rice.

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References

Aini, N., Munarso, J., Annisa, F. S., & Jayanthi, T. T. (2020). Karakteristik Beras Analog Dari Tepung Jagung- Kacang Merah Mengunakan Agar-Agar Sebagai Bahan Pengikat. *Jurnal Penelitian Pascapanen Pertanian*, *16*(1), 1. https://doi.org/10.21082/jpasca.v16n1.2019.1-9

Akbar, Winarti, S., & Rosida. (2023). Pengaruh Proporsi Tepung Sagu (Metroxylon spp.) dan Tepung Gembili (Discorea esculentra) dengan Penambahan Gliserol Monostearat Terhadap Karakteristik Mi Basah. *G-Tech: Jurnal Teknologi Terapan*, *7*(3), 778–787. https://doi.org/10.33379/gtech.v7i3.2516

AOAC. (2005). *Official Method of Analysis. 18th Edition, Association of Officiating Analytical Chemists*.

Aoe, S. (2015). Effects of liquid konjac on obesity-related parameters in mice with diet-induced obesity *Bioscience, Biotechnology and Biochemistry*, *79*(7), 1141–1146. https://doi.org/10.1080/09168451.2015.1018119

BPS. (2019). *Impor Beras Menurut Negara Asal Utama*. http://bps.go.id

BPS. (2023). *Impor Beras Menurut Negara Asal Utama, 2000-2022*. BerandaProduk - Tabel StatistikPertanian, Kehutanan, Perikanan. https://www.bps.go.id/id/statistics-table/1/MTA0MyMx/impor-beras-menurut-negara-asal-utama--2000-2022.html

BRIN. (2024). *Diversifikasi Pangan Lokal Kunci Penting Atasi Tantangan Ketahanan Pangan*. https://www.brin.go.id/news/121811/diversifikasi-pangan-lokal-kunci-penting-atasi-tantangan-ketahanan-pangan

Budi, F. S. (2013). *Teknologi Proses Ekstrusi untuk Membuat Beras Analog (Extrusion Process Technology of Analog Rice)*. https://api.semanticscholar.org/CorpusID:113582264

Budi, F. S., Hariyadi, P., Budijanto, S., & Syah, D. (2017a). Kristalinitas dan Kekerasan Beras Analog yang Dihasilkan dari Proses Ekstrusi Panas Tepung Jagung. *Jurnal Teknologi Dan Industri Pangan*, *28*(1 SE-Research Paper), 46–54. https://doi.org/10.6066/jtip.2017.28.1.46

Budi, F. S., Hariyadi, P., Budijanto, S., & Syah, D. (2017b). Kristalinitas Dan Kekerasan Beras Analog Yang Dihasilkan Dari Proses Ekstrusi Panas Tepung Jagung. *Jurnal Teknologi Dan Industri Pangan*, *28*(1), 46–54. https://doi.org/10.6066/jtip.2017.28.1.46

Budijanto, S. (2017). *Karakteristik Fisik, Kimia, dan Sensori Beras Analog Berbasis Bahan*

Pangan Non Beras. https://api.semanticscholar.org/CorpusID:116181879

Bui, L. T. T., Coad, R. A., & Stanley, R. A. (2018). Properties of rehydrated freeze dried rice as a function of processing treatments. *LWT*, *91*, 143–150. https://doi.org/https://doi.org/10.1016/j.lwt.2018.01.039

Damat, D., Natazza, R., & Wahyudi, V. (2020). Kajian Pembuatan Beras Analog Berbasis Tepung Komposit dengan Penambahan Konsentrasi Bubur Rumput Laut (Gracilaria sp.) dan Gliserol Monostearat. *Food Technology and Halal Science Journal*, *3*, 174. https://doi.org/10.22219/fths.v3i2.13218

Dewi, G. P., & Ginting, A. M. (2012). Antisipasi Krisis Pangan melalui Kebijakan Diversifikasi Pangan. *Jurnal Ekonomi & Kebijakan Publik*, *3*(1), 66–75.

Diniyah, N., Puspitasari, A., Nafi, A., & Subagiao, A. (2016). Digital Digital Repository Repository Universitas Universitas Jember Jember Digital Digital Repository Repository Universitas Universitas Jember Jember. *Jurnal Penelitian Pascapanen Pertanian*, *13*(1), 36–42.

Du, Q., Liu, J., & Ding, Y. (2021). Recent progress in biological activities and health benefits of konjac glucomannan and its derivatives. *Bioactive Carbohydrates and Dietary Fibre*, *26*(June), 100270. https://doi.org/10.1016/j.bcdf.2021.100270

Fauziyah, A., Marliyati, S. A., & Kustiyah, L. (2017). Substitusi Tepung Kacang Merah Meningkatkan Kandungan Gizi, Serat Pangan Dan Kapasitas Antioksidan Beras Analog Sorgum. *Jurnal Gizi Dan Pangan*, *12*(2), 147–152. https://doi.org/10.25182/jgp.2017.12.2.147-152

Faza, F., Bafani, U. F. F., & Fikha, I. I. (2023). Makanan Ultra-Proses Berperan sebagai Mediator Hubungan Ketahanan Pangan dengan Status Kelebihan Gizi atau Obesitas pada Dewasa: Literature Review. *Amerta Nutrition*, *7*(1), 161–174. https://doi.org/10.20473/amnt.v7i1.2023.16

Fikha, I. (2023). Hubungan Kerawanan Pangan dengan Obesitas pada Orang Dewasa. *Nutriology : Jurnal Pangan,Gizi,Kesehatan*, *4*, 65–70. https://doi.org/10.30812/nutriology.v4i2.3385

Fikha, I. I. (2023). Hubungan Kerawanan Pangan dengan Obesitas pada Orang Dewasa. *Nutriology : Jurnal Pangan,Gizi,Kesehatan*, *4*(2), 65–70. https://doi.org/10.30812/nutriology.v4i2.3385

Finirsa, M. A., Warsidah, W., & Sofiana, M. S. J. (2022). Karakteristik Fisikokimia Beras Analog dari Kombinasi Rumput Laut Eucheuma cottoni, Mocaf dan Sagu. *Oseanologia*, *1*(2), 69. https://doi.org/10.26418/jose.v1i2.54566

Handayani, D., Nurwantoro, N., & Pramono, Y. B. (2022). Karakteristik Kadar Air, Kadar Serat dan Rasa Beras Analog Ubi Jalar Putih dengan Penambahan Tepung Labu Kuning. *Jurnal Teknologi Pangan*, *6*(2), 14–18. https://doi.org/10.14710/jtp.2022.26035

Hardono, G. (2016). Strategi Pengembangan Diversifikasi Pangan Lokal. *Analisis Kebijakan Pertanian*, *12*, 1. https://doi.org/10.21082/akp.v12n1.2014.1-17

Jain, A., Sarsaiya, S., Gong, Q., Wu, Q., & Shi, J. (2025). Amorphophallus konjac: traditional uses, bioactive potential, and emerging health applications. *Frontiers in Plant Science*, *16*(February), 1–20. https://doi.org/10.3389/fpls.2025.1530814

Jariyah, J., & Vestra, A. (2023). Karakteristik Beras Analog dari Tepung Komposit (Mocaf: Sagu: Kedelai: Daun Kelor) dengan Penambahan Karagenan. *Jurnal Teknologi Hasil Pertanian*, *16*(2), 94. https://doi.org/10.20961/jthp.v16i2.61507

Kemenkes RI. (2018). Tabel Komposisi Pangan Indoensia 2017. In *Kementerian Kesehatan Republik Indonesia*.

Kemenkes RI. (2020). *Tabel Komposisi Pangan Indonesia* (2020th ed.). Kemenkes BKPK.

Kementerian Kesehatan RI. (2023). *Panduan Hari Obesitas Sedunia*. 1–26.

Khairunnisa, K., Budijanto, S., & Sitanggang, A. B. (2017). Formulation of High Protein Rice Analog Made of Cassava , Maize Starch , and Soybean. *Proceedings of the 24th Tri-University International Joint Seminar and Symposium 2017*, *01*(November), 105.

Kocadağlı, T., & Gökmen, V. (2018). *Caramelization in Foods: A Food Quality and Safety Perspective*. https://doi.org/10.1016/B978-0-08-100596-5.21630-2

Kurniasari, I., Kusnandar, F., & Budijanto, S. (2020a). Karakteristik Fisik Beras Analog Instan Berbasis Tepung Jagung dengan Penambahan k-Karagenan dan Konjak. *AgriTECH*, *40*(1), 64. https://doi.org/10.22146/agritech.47491

Kurniasari, I., Kusnandar, F., & Budijanto, S. (2020b). Karakteristik Fisik Beras Analog Instan Berbasis Tepung Jagung dengan Penambahan k-Karagenan dan Konjak. *AgriTECH*, *40*, 64. https://doi.org/10.22146/agritech.47491

Kusnandar, F., Budi, F. S., Indrasti, D., Annisa, N., & Abraham, K. G. (2024). *Karakteristik mutu fisik , kimia dan umur simpan beras analog dari campuran tepung ubi jalar ungu , jagung dan sagu*. *18*(2), 333–342. https://doi.org/10.21107/agrointek.v18i2.17352

Kusnandar, F., Noviasari, S., Setiyono, A., & Budijanto, S. (2015). Beras Analog Sebagai Pangan Fungsional Dengan Indeks Glikemik Rendah. *Jurnal Gizi Pangan*, *10*(3), 225–232.

Latief, R., Asfar, M., Chairany, M., & Djalal, M. (2023). Effect of Porang Flour (Amorphophallus Muelleri) as A Fat Replacer on the Acceptability and Characteristics of Cookies. *Jurnal Penelitian Pendidikan IPA*. https://api.semanticscholar.org/CorpusID:259764687

López-Cepero, A., Frisard, C., Lemon, S. C., & Rosal, M. C. (2020). Emotional Eating Mediates the Relationship Between Food Insecurity and Obesity in Latina Women. *Journal of Nutrition Education and Behavior*, *52*(11), 995–1000. https://doi.org/https://doi.org/10.1016/j.jneb.2020.08.007

Morales, M. E., & Berkowitz, S. A. (2016). The Relationship between Food Insecurity, Dietary Patterns, and Obesity. *Current Nutrition Reports*, *5*(1), 54–60. https://doi.org/10.1007/s13668-016-0153-y

Murata, M. (2021). Browning and pigmentation in food through the Maillard reaction. *Glycoconjugate Journal*, *38*(3), 283–292. https://doi.org/10.1007/s10719-020-09943-x

Nguyen, B. T., Shuval, K., Bertmann, F., & Yaroch, A. L. (2015). The Supplemental Nutrition Assistance Program, Food Insecurity, Dietary Quality, and Obesity Among U.S. Adults. *American Journal of Public Health*, *105*(7), 1453–1459. https://doi.org/10.2105/AJPH.2015.302580

Ningtyastuti, D., Damat, D., & Winarsih, S. (2023). Karakteristik Fisiko-Kimia Beras Analog Kombinasi Dari Pati Sagu, Tepung MOCAF, Tepung Porang (Amorphophallus muelleri), dan Tepung Kedelai. *Food Technology and Halal Science Journal*, *5*(2), 220–230. https://doi.org/10.22219/fths.v5i2.22053

Novikasari, N. A. M., Muflihati, I., Hasbullah, U. H. A., & Ujianti, R. M. D. (2023). Uji kandungan gizi dan perbandingan sifat sensoris beras analog dari tepung cassava dengan penambahan tepung kacang hijau. *Agrointek*, *17*(2), 306–316. https://doi.org/10.21107/agrointek.v17i2.13925

Prabowo, A. Y., Estiasih, T., & Purwantiningrum, I. (2014). Umbi Gembili (Dioscorea esculenta L.) sebagai Bahan Pangan Mengandung Senyawa Bioaktif: Kajian Pustaka. *Jurnal Pangan Dan Agroindustri*, *2*(3), 129–135.

Rachma, O. R., Damat, D., & Manshur, H. A. (2023). Kajian Karakteristik Fisikokimia dan Organoleptik Beras Analog Berbahan Dasar Tepung Gembili (Dioscorea aculleata. L), Tepung Jagung (Zea mays, L) dan Pati Sagu (Metroxylon sp). *Food Technology and Halal Science Journal*, *5*(2), 125–136. https://doi.org/10.22219/fths.v5i2.21911

Rahayu, N., Kusuma Wardani, M., Prarudiyanto, A., & Zainuri, Z. (2023). Penambahan Tepung Porang Sebagai Alternatif

Pengganti Bahan Pengenyal Sintetis Pada Produk Bakso Ikan Kurisi. *Pro Food*, *9*(1), 46–57. https://doi.org/10.29303/profood.v9i1.310

Ratnaduhita, A., Pratama, Y., & Pramono, Y. B. (2022). Karakteristik Kimia dan Tingkat Kesukaan Beras Analog "GATOT KACA" dari Gatot dan Kacang Merah (Phaseolus vulgaris L.) dengan Variasi Konsentrasi CMC (Carboxymethyl Cellulose). *Jurnal Teknologi Pangan*, *5*(1), 13–17. https://doi.org/10.14710/jtp.2021.23402

Sabda, M., Wulanningtyas, H. S., Ondikeleuw, M., & Baliadi, Y. (2019). Karakterisasi Potensi Gembili (Dioscorea esculenta L.) Lokal Asal Papua Sebagai Alternatif Bahan Pangan Pokok. *Buletin Plasma Nutfah*, *25*(1), 25–32.

Saloko, S., Widyastuti, S. H., Rumiyati, R., Rosmilawati, R., & Fitriani, M. (2020). *Inovasi Teknologi Beras Sehat Analog Fungsional Untuk Kesejahteraan Masyarakat*. https://api.semanticscholar.org/CorpusID:225890509

Setyaningsih, A., Mulyasari, I., Afiatna, P., & Putri, H. R. (2024). The Relationship between Ultra-Processed Food Consumption with Diet Quality and Overweight Status in Young Adults. *Amerta Nutrition*, *8*(1), 124–129. https://doi.org/10.20473/amnt.v8i1.2024.124-129

Sirotin, N., Hoover, D. R., Shi, Q., Anastos, K., & Weiser, S. D. (2014). Food insecurity with hunger is associated with obesity among HIV-infected and at risk women in Bronx, NY. *PloS One*, *9*(8), e105957. https://doi.org/10.1371/journal.pone.0105957

Srihari, E., Lingganingrum, F. S., Alvina, I., & Anastasia. (2016). Rekayasa Beras Analog Berbahan Dasar Campuran Tepung Talas, Tepung Maizena dan Ubi Jalar. *Jurnal Teknik Kimia*, *11*(1), 14–19.

Sripinyowanich, J., & Noomhorm, A. (2013). Effects of freezing pretreatment, microwave-assisted vibro-fluidized bed drying and drying temperature on instant rice production and quality. *Journal of Food Processing and Preservation*, *37*(4), 314–324. https://doi.org/10.1111/j.1745-4549.2011.00651.x

Unicef. (2023). Analisis Lanskap Kelebihan Berat Badan dan Obesitas di Indonesia. *Unicef*, 6. https://www.unicef.org/indonesia/media/16691/file/Ringkasan untuk Pemangku Kebijakan.pdf

Utami, R., Widowati, E., & Dewati, A. D. A. R. (2013). Kajian Penggunaan Tepung Gembili (Dioscorea esculenta) Dalam Pembuatan Minuman Sinbiotik Terhadap Total Bakteri Probiotik, Karakter Mutu, dan Karakter Sensoris. *Jurnal Teknosains Pangan*, *2*(3), 3–8.

WHO. (2024). *Obesity: Health consequences of being overweight*. Home/Newsroom/Questions and Answers. https://www.who.int/news-room/questions-and-answers/item/obesity-health-consequences-of-being-overweight#:~:text=Being overweight or obese can,endometrial%2C breast and colon).

Yanuriati, A., Marseno, D. W., & Harmayani, E. (2017). Characteristics of glucomannan isolated from fresh tuber of Porang (Amorphophallus muelleri Blume). *Carbohydrate Polymers*, *156*, 56–63.

Yofananda, O., & Estiasih, T. (2016). Potensi Senyawa Bioaktif Umbi-umbian Lokal Sebagai Penurun Kadar Glukosa Darah: Kajian Puataka. *Jurnal Pangan Dan Agroindustri*, *4*(1), 410–416.

Yudanti, R. Y., & Waluyo, S. (2015). Pembuatan Beras Analog Berbahan Dasar Tepung Pisang (Musa paradisiaca). *Pembuatan Beras Analog Berbahan Dasar Tepung Pisang (Musa Paradisiaca)*, *4*(2), 117–126