International Summit on Science Technology and Humanity (ISETH) 2021
Enhancement of Academic Capacity to Contribute Country Development
p-ISSN: 2477-3328
e-ISSN: 2615-1588

Functional Properties of Instant Yellow Rice of Gembili Tubers *(Dioscorea esculenta)* to Improve Food Security

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ABSTRACT

Gembili tubers have sufficient carbohydrate content compared to other tubers. Gembili tubers contain bioactive compounds that can be beneficial for the body. The antioxidants contained in gembili tubers are phenol, diosgenin, and dioscorin. Dietary fiber is also contained in gembili tubers which can provide benefits for the body such as overcoming diabetes, preventing digestive disorders, lowering cholesterol levels. These tubers can be processed into tuber flour, starch, and composite flour. In addition, this tuber can be used as an alternative non-rice food source. Turmeric as a colorant for instant yellow rice of gembili tubers which contains antioxidants, anti-inflammatory, antimutagenic, anticancer, and antimicrobial properties. So far, no one has made instant yellow rice made from gembili tubers.

Purpose: The research is aimed to determine the content of antioxidants activity and dietary fibers in instant yellow rice from gembili tubers with different drying temperature variations of 70°C, 80°C, and 90°C.

Methodology: The experiment of instant yellow rice was conducted using a single-factor Completely Randomized Design (CRD) method with temperature variations of 70°C, 80°C, and 90°C for three hours. Testing of dietary fiber using the multienzyme method and testing of antioxidant activity using the RSA IC_{50} method. The research was carried out in two treatment replications with two laboratory analyzes. Furthermore, the obtained data were analyzed using the One-Way ANOVA test, and if the results showed a treatment effect, then proceed using the DMRT test with = 5%.

Results: The results of this study showed that the dietary fiber content of instant yellow rice from Gembili tubers had no effect on variations in drying temperature with $p = 0.685$ ($p \geq 0.05$). However, based on three different temperature treatments, the highest dietary fiber content was at 70°C temperature treatment, which was 10.8047%. Whereas antioxidant activity tests on instant yellow rice of Gembili tubers indicated that there was an effect of drying temperature variations on antioxidant activity with $p = 0.001$ ($p < 0.05$). The variation of the drying temperature of 90°C shows the highest antioxidant activity, which is 6162,7008 ppm. The lower of the drying temperature, so the lower of the level antioxidant activity.

Applications/Originality/Value: This diversification product of instant yellow rice of gembili tubers is expected can support the national food security program by reducing rice consumption rate without causing substantial change in the tradition of the Indonesian people.

Keywords: gembili tubers, turmeric, instant yellow rice, antioxidant, dietary fiber

INTRODUCTION

Rice (*Oryza sativa*) is the main source of carbohydrate in the dietary habit in Indonesian. The increasing of rice consumption rate in Indonesia has unsurprisingly become the key factor to the import of rice every year. The highest amount of rice import by the Indonesian government occurred in 2018, with ballooning figure of 2,253,000 tonnes (BPS, 2019). This dependency of the Indonesians to rice will undoubtedly rise concern about food security in the archipelago nation. Food security in Indonesia can be upgraded by increasingly harnessing local comestibles other than rice. Indonesia is home to numerous varieties of non-rice local food ingredients such as corn, cassava, sweet potato, sorghum, sago, and many others (BKP, 2020). Tuber is one of carbohydrate-rich commodities, yet is still not widely explored in Indonesia. Tuber is local ingredient that needs more proper preservation and utilization. According to the Indonesian Food Security Agency (BKP), the consumption of tubers family in 2018 is as follows: cassava (9.5 kg/capita/year), sweet potato (3.4 kg/capita/year), potato (2.4 kg/capita/year), sago (0.4 kg/capita/year) (BKP, 2018). Compared to the data from 2018, tuber's

consumption experiences a decline. The result above urges an improvement in tubers consumption in order to become an alternative source of carbohydrate to rice. Gembili tubers are one of the tubers that are often found in Central Java but are still underutilized. Therefore, one of the innovations that can be produced to increase the use value and consumption level of gembili tubers is to process them into processed food products.

One of the lesser-known tubers in Indonesia with undoubted nutrients and benefits is gembili tubers (*Dioscorea esculenta*). Gembili is highly beneficial for human body because it contains bioactive compounds. The tuber's utilization can be obtained by turning it into tuber flour, starch, or composite flour. Every 100 grams of gembili, with edibility rate of 85%, contains 131 kcal of energy, 1.1 g of protein, 0.2 g of fat, 31.3 g of carbohydrate, 1.1 g of fiber, 56 mg of phosphor, 0.6 mg of iron, 14 mg of calcium, as well as 4 mg and 0.08 mg of vitamin C and vitamin B1, respectively (Izwardy D et al., 2017). Gembili has eminence contents of bioactive compounds in the forms of diosgenin, dioscorin, inulin (Masrikhiyah, 2019) and also has insoluble fiber in the shape of cellulose, as well as little lignin and hemicellulose. The function of these antioxidant compounds is as an antidote to free radicals (Mar'atirrosyidah & Estiasih, 2015). It possesses tuber flour and starch yields of 21.40% and 24.28%; the highest among other tubers. The yields of gembili have profound potential to be produced as flour or starch (Sabda et al., 2019).

Indonesians' basic food needs of "nasi" (cooked rice, simply "rice" here forward) is irreplaceable for now. Rice is still the main, must-consume comestible for Indonesian. There several types of rice consumed in Indonesia, including nasi uduk, nasi liwet, and nasi kuning (Abidjulu et al., 2015). Nasi kuning (yellow rice) is basically made of rice grains, turmeric, alongside many other ingredients and spices. Yellow rice has long been a part of the main food of Indonesian society. Yellow rice is usually consumed in the morning, afternoon, and evening. Although previously yellow rice was only consumed in certain cultural traditions such as thanksgiving, weddings, and birth (Indriani, 2012). Therefore, yellow rice is familiar to the people of Indonesia. So this product is an innovation from yellow rice with the basic ingredients of gembili tubers.

Turmeric, that gives the cuisine its iconic yellow colour, contains curcumin compounds, which is a polyphenol compounds that acts as antioxidant, antiinflammation, antimutagenic, anticancer, and antimicrobe (Hewlings & Kalman, 2017). Turmeric mixed in nasi kuning yields beautiful and appealing appearance. Other than that, turmeric is also beneficial for human health (Auza & Tasse, 2015).

One of the efforts that can be carried out to reduce rice dependency in Indonesia is food diversification by processing gembili tubers into instant yellow rice. The production cycle of instant yellow rice of gembili tubers is divided into two processes; the flouring of gembili tubers and the making of instant yellow rice with temperature variations of 70°C, 80°C, 90°C. Drying process also has effects on nutrient content; the level of nutrient content decrease in a foodstuff due to heating depends on the type of ingredient and temperature used, which can affect the quality of the food (Sundari, 2016). This research aims to measure the effect of temperature variations on antioxidant and fiber contents of instant yellow rice of gembili tubers. This diversification product of instant yellow rice of gembili tubers is expected to support the national food security program by reducing rice consumption rate without causing substantial change in the tradition of the Indonesian people.

RESEARCH METHODS

Materials

The materials used in the flouring process are gembili tubers (obtained from Sambi traditional market, Boyolali), Na-Bisulphite and salt. Ingredients for the making instant yellow rice of Gembili tubers include gembili tuber flour, turmeric (obtained from Kleco traditional market, Surakarta), sodium triphosphate (STPP), alginate, calcium chloride, cooking oil, dan aquadest. Ingredients for fiber level analysis are phosphate buffer pH 7, alpha amylase enzyme, distilled water, HCl solution 1N,

p-ISSN: 2477-3328
e-ISSN: 2615-1588

pepsin enzyme, NaOH solution 1N, beta amylase enzyme, ethanol, acetone, ethanol 95%. Ingredients for antioxidant activities analysis are 1 ,1 ,2 ,2 –Diphenyl Picrylhydrazyl (DPPH) solution and methanol.

Research Stages

1. Flouring of Gembili Tubers

   Gembili used for flouring in this research were 5 – 10 cm long with diameter of 2 – 3 cm. The flouring process was based on the methods by Winarti et al., (2017) with modifications. The process was begun by peeling and slicing the tubers by thickness of 2 – 3 mm, soaking in Na-Bisulphite and salt for 6 – 8 hours, drying in the sunfor 3 – 4 days, milling to make flour, and sifting using 80-mesh sieve.

2. Making of Instant Yellow Rice of Gembili Tubers

   The making of instant yellow rice of Gembili tubers consisted of several steps based on the research by Arifiani, Rizky dan Sulandari (2016) with modifications. First step was manually mixing dough by hands for 15 – 20 minutes until it became smooth and homogenous. The mixture consisted of 200 grams of gembili flour, 0.4 grams of STPP, 4 grams of alginate, 0.2 grams of calcium chloride, 20 grams of cooking oil, and 100 ml of aquadest. Next, adding 20 grams of liquid turmeric extract which was previously gained by grating peeled and washed turmeric, mixing it with 100 ml of aquadest, then filtering the final yellow mixture. The dough was then manually moulded into the shape of rice. Finally, instant yellow rice of Gembili tubers was dried in the oven (with temperature variations of 70°C, 80°C, and 90°C for 3 hours).

3. Dietary Fiber Analysis of Instant Yellow Rice of Gembili Tubers

   The quality testing of instant yellow rice of Gembili tubers included functional characteristics testing of dietary fiber content. Dietary fiber content testing was conducted using the Gravimetry/ Multienzyme methods (AOAC, 2006).

4. Antioxidant Activity Analysis of Instant Yellow Rice of Gembili Tubers

   The quality testing of instant yellow rice of Gembili tubers included functional characteristics testing of antioxidant activity was done using the DPPH RSA IC_{50} (Radical Scavenging Activity) methods.

Research Design

This is experimental research using single-factor Completely Randomized Design (CRD) method with three temperature variations drying. The treatment variation lies in the applied temperatures of 70°C, 80°C, and 90°C. The experiment is repeated two times for each treatment. Each repetition is given two times of analysis.

Statistical Analysis

Statistical analysis is then conducted to the laboratory results of normality and homogeneity tests. If the data turns out normal and homogenous, then the One-Way ANOVA test is carried out; and if there is any effect of treatment, then data is proceeded using the DMRT test with $\alpha = 5\%$.

RESULT AND DISCUSSION

Instant Yellow Rice of Gembili Tubers

Figure 1 is the result of the first experiment and Figure 2 is the result of the second experiment of making gembili tubers instant yellow rice with different drying temperature variations of 70°C, 80°C, and 90°C, where in the picture the plate on the left is an instant yellow rice product with a drying temperature of 70°C, the middle plate use 80°C, and the plate on the right use 90°C.

Figure 1. Instant Yellow Rice of Gembili Tubers Experiment I

Figure 2. Instant Yellow Rice of Gembili Tubers Experiment II

Total Dietary Fiber of Instant Yellow Rice of Gembili Tubers

Dietary fiber is carbohydrate and lignin which cannot be hydrolysed by human digestive enzymes. Codex Alimentarius Commission (CAC, 2009) defines dietary fiber as carbohydrate polymers with ten or more monomer units which cannot be digested or absorbed by human small intestines and falls into these three categories: (i) naturally edible carbohydrate polymers in edible foods, (ii) edible carbohydrate polymers from physical, enzymatical, or chemical food raw materials and have beneficial physiological effects that have been scientifically proven and generally accepted, (iii) synthetic edible carbohydrate polymers with have beneficial physiological effects that have been scientifically proven and generally accepted. Total Dietary Fiber (TDF) consists of soluble dietary fiber (SDF) and insoluble dietary fiber (IDF). Soluble dietary fiber is dietary fiber that can be dissolved in water. Whereas insoluble dietary fiber is dietary fiber that cannot be dissolved in water (Santoso, 2011).

Table 1. shows the results of total dietary fiber tests instant yellow rice of gembili tubers with three drying temperature variations in two experiments. The results show that lower drying temperature in the making of instant yellow rice of Gembili tubers leads to higher dietary fiber content.

Normality tests concluded that data were normally distributed since the value of $p = 0.2$ ($p > 0.05$). While homogeneity tests indicated that data were homogenous since the value of $p = 0.23$ ($p > 0.05$). Furthermore, the One-Way ANOVA test showed values of $p = 0.685$ ($p \geq 0.05$) that implied there was zero effects of different temperature treatments to the dietary fiber content.

Table 1. Dietary Fiber by Treating Variations in Drying Temperature on Instant Yellow Rice of Gembili Tubers

Temperature Variations	Dietary Fiber (%)	*p*
	1	
70°C	10,8047	
80°C	10,4329	0,685
90°C	10,3649	

p-ISSN: 2477-3328
e-ISSN: 2615-1588

The One-Way ANOVA test conducted on three drying temperatures in the process of making gembili instant yellow rice showed that the highest dietary fiber content occurred on 70°C temperature treatment, whereas the 90°C treatment returned the lowest fiber content occurred. This result falls in line with a study by (Sandrin et al., 2019)the effect of extrusion temperature and screw speed on the nutritional properties of the extrudates was evaluated by using a response surface methodology. The total, soluble, insoluble dietary fiber, beta-glucan, resistant starch, and total starch contents were evaluated through enzymatic assays. The processing parameters affected the content of all constituents of the flour mixture, except for beta-glucan. The total starch content, insoluble dietary fiber, and resistant starch were significantly decreased with increasing temperature and screw speed (until 13, 12, and 97%, respectively, which dealt with temperature applied in the extrusion process to prepare fiber-rich oat flour, that found that higher temperature will simultaneously decrease dietary fiber content. Two years later, a research by Sumardiono et al. (2021) presented that drying temperature on extrusion methods of making analogue rice with the highest dietary fiber content found on 90°C, compared to other temperature treatments of 50°C and 70°C. The fiber content decrease was caused by decay on the cell wall of the analogue rice during the extrusion process. The fiber content rise happened due to decrease of water content on the analogue rice which evaporated during the extrusion process. However, other compounds' content such as carbohydrate increased which led the dietary fiber content to increase as well.

The fiber content on the instant yellow rice of Gembili tubers with three different temperature treatments produced the value of 10.3649% to 10.8047%. So that it is safe to say that instant yellow rice of Gembili tubers is high-fiber food. According to CAC (2009), high-fiber food contains minimum dietary fiber of 6%, while food to be categorized as fiber source needs to contain minimum dietary fiber of 3%. Raw gembili tubers have a dietary fiber content of 1.1 g in every 100 g with an edible weight of 85% (Izwardy D et al., 2017). If calculated in percent, gembili tubers have 6,386% dietary fiber (Pratiwi et al., 2016). So that the dietary fiber in instant yellow rice of Gembili tubers is higher than raw gembili tubers.

Dietary fiber has plenty benefits such as providing longer feeling of fullness, controlling body weight, and reducing fat content by binding it in small intestines (Herminingsih, 2010). Muchtadi (2000) as cited in Nurdjanah & Elfira (2009) wrote that dietary fiber can increase water content in colon that can prevent cancer, as well as form softer and bigger feces that can prevent diverticular disease.

Previous studies on dietary fiber using the gravimetric test showed that higher temperature will reduce dietary fiber content. Instant yellow rice of Gembili tubers, that falls into analogue rice category, has higher fiber content of 5.35% to 6.14% than that of sosoh rice Elleuch et al as cited in Noviasari et al. (2015). It can be concluded that instant yellow rice of Gembili tubers can be categorized as high-fiber food for its high dietary fiber content. According to recommendation of American Dietetic Association (ADA), daily dietary fiber consumption for adults is 20 – 35 g/day. Moreover, dietary fiber will also reduce the risk of cardiac disease if consumed more than 25 g/day (CAC, 2009).

Dietary fiber is a polysaccharide compound that is not easily digested by digestive enzymes which is then fermented in the intestine. Dietary fiber is related to the glycemic index value of a food ingredient, the higher the dietary fiber the lower the glycemic index value. Gembili is a tuber that has high dietary fiber, which is 6.386% (Winarti et al., 2017). The advantages of gembili are that they contain bioactive compounds, namely inulin which is a soluble dietary fiber and high dietary fiber, the inulin content in gembili tubers is 14.77% which is high when compared to other types of tubers. Inulin can be used as a prebiotic. Prebiotics are types of food fiber that are not digested by digestive enzymes but are fermented by microflora in the large intestine and will have a good effect on body health, one of which can facilitate digestion (Winarti et al., 2017). Research on the prebiotic activity of gembili tuber inulin was carried out with the foam mat drying method. Inulin drying was carried out using a temperature of 60°C for 3 hours and the results showed that the value of prebiotic activity was

high. The fiber content contained in gembili tubers based on the processing method. Foresters carry out processing of gembili tubers by boiling, frying, and steaming, then the processed products are analyzed for fiber content using the enzymatic method. The results of this study showed the highest fiber content in fried gembili, where the content of insoluble dietary fiber was higher than the content of soluble dietary fiber.

Antioxidant Activities of The Instant Yellow Rice of Gembili Tubers

Antioxidant is chemical compound that gives out one or more electron to free radicals to hinder them to react. Other explanation describes antioxidant as a compound that can prevent or hinder oxidation on an oxidated substance (Mar'atirrosyidah & Estiasih, 2015). Antioxidant is divided into two types which are enzymatic and nonenzymatic antioxidants. The enzymatic antioxidant is an antioxidant that has characteristics of prevention, while nonenzymatic antioxidant is an antioxidant that can break the chain caused by lipid peroxidation processes. Antioxidants found in gembili tubers are phenol, diosgenin, and dioscorin. Phenol is secondary metabolite with single aromatic ring and contains one hydroxyl group or more. The mechanism of phenol compound in donating electrons is called phenol acting as antioxidant. Diosgenin is an antioxidant that increases DNA lymphocytes' resistance to damage against oxidative compounds, anti-aging activities, cholesterol and fat secretions from within bile, and is also able to inhibit the growth of cancer cells. Dioscorin is a water-soluble alkaloid compound. This compound acts as immunomodulatory and is able to hold up angiotensin converting enzyme (ACE) which translates to causing increase in blood pressure Shajeela as cited in Mar'atirrosyidah & Estiasih (2015).

Table 2. shows results gained from two antioxidant activities tests of instant yellow rice of Gembili tubers on each of three drying temperature variations. The results indicate that lower drying temperature applied in the making of instant yellow rice of Gembili tubers resulted in lower antioxidant activities content. Antioxidants are compounds that can counteract free radicals and prevent degenerative diseases (Najihudin et al., 2017). Antioxidants have curcuminoid compounds that function as anti-inflammatory, antihepatoxic, antitumor, and can lower body cholesterol. The phenolic components in turmeric can prevent cancer growth (Salim et al., 2017).

The normality tests showed that data were normally distributed since the value of $p = 0.051$ ($p > 0.05$). Whereas homogeneity tests concluded that data were homogenous since the value of $p = 0.242$ ($p > 0.05$). Then, the One-Way ANOVA tests returned the value of $p = 0.001$ ($p < 0.05$) which indicated that there were effects of drying temperature variations to the antioxidant activities of instant yellow rice of Gembili tubers. As the data suggests, the highest antioxidant activities among the three temperature treatments was on the drying temperature of 90°C.

Table 2. Antioxidant Activity by Treating Variations in Drying Temperature on Instant Yellow Rice of Gembili Tubers

Temperature Variations	Antioxidant Activity (%)	
	1	2
70°C		7136,4835[a]
80°C	6354,2963[b]	
90°C	6162,7008[b]	

According to the Duncan test, there was no significant distinction between 80°C and 90°C temperature variations, while the 70°C temperature showed different result. It means that the doughs with strongest antioxidant activities were the results of 80°C and 90°C drying temperatures, because smaller IC_{50} value means higher antioxidant activities (Widyasanti et al., 2016).

p-ISSN: 2477-3328
e-ISSN: 2615-1588

Molyneux (2004) wrote that lower IC_{50} value indicates higher antioxidant activities. Very strong antioxidant activities category has IC_{50} < 50 ppm, strong has IC_{50} 50 – 100 ppm, intermediate has IC_{50} 100 – 150 ppm, weak has IC_{50} 150 – 200 ppm, and very weak has IC_{50} > 200 ppm. Results obtained from the aforementioned experiments showed that instant yellow rice of Gembili tubers possesses very weak antioxidant activities with IC_{50} > 200 ppm. However, drying temperature of 90°C applied to the rice showed higher antioxidant activities than other treatments of 70°C and 80°C. In this product, turmeric is added as an additive to natural dyes. The result of antioxidant activity in yellow rice is 6162,7 ppm, while raw turmeric has an antioxidant of 40-200 ppm (Gayatri & Sahu, 2011).

The coloring of instant yellow rice of Gembili tubers used turmeric liquid diluted with aquadest. According to (Khatun et al., 2006), turmeric is one of spices with high antioxidant activities and its phenol content can be extracted using ethanol 20%. Research done by Boeing et al. (2014) explained that extraction using organic solvent and water is more effective than using water alone. It is because of the polarity level suitability between anthocyanin and mixture of ethanol and water. Whereas water solvent is very polar. Palleros (1993) as cited in Setyowati & Suryan (2014) that water can dissolve various organic compounds with 5 carbon chains or less as well as inorganic compounds due to its high polarity. While ethanol has medium polarity that can dissolve organic compounds.

This research is not in accordance with the study by Cahyani et al. (2019) about temperature and Ambon banana peel flour drying time variations against antioxidant activities. In her experiments, higher temperature led to antioxidant activities decline due to heating that caused antioxidant compounds to become sensitive to high temperatures.

Antioxidants can be found in plants containing high polyphenol compounds, such as turmeric (Tristantini et al., 2016) and plants containing bioactive compounds, such as gembili tubers (Mar'atirrosyidah & Estiasih, 2015). Antioxidants in turmeric, namely curcuminoid compounds function as anti-inflammatory, antihepatoxic, antitumor, and can lower body cholesterol. The phenolic components in turmeric can prevent cancer growth (Salim et al., 2017). The antioxidants contained in gembili tubers are in the form of bioactive compounds, including phenol, diosgenin, and dioscorin. The function of these antioxidant compounds is as an antidote to free radicals (Mar'atirrosyidah & Estiasih, 2015).

Research from (Agustikawati et al., 2017) regarding the antioxidant activity of turmeric powder extract related to temperature and drying time with the DPPH test method showed the highest antioxidant activity at a temperature of 40°C with a drying time of 18 hours, while drying at a temperature of 60°C for 10 hours had the highest antioxidant activity value. Antioxidant activity was higher than the temperature of 50°C for 14 hours. Similarly, research from (N.E.W.D.S et al., 2020) on the effect of drying time on flakes made from gembili tuber flour and purple sweet potato which tested antioxidant activity with the DPPH test method showed the highest antioxidant activity results in an oven for 40 minutes at a temperature of 150°C. The comparison of time used is 40 minutes, 45 minutes, and 50 minutes.

CONCLUSION

One of the efforts that can be carried out to reduce rice dependency in Indonesia is food diversification by processing gembili tubers into instant yellow rice. Variations in temperature treatment in the making instant yellow rice of Gembili tubers did not show any effect on dietary fiber content with $p = 0.685$ ($p \geq 0.05$). Whereas antioxidant activity tests on instant yellow rice of Gembili tubers indicated that there was an effect of drying temperature variations on antioxidant activity with $p = 0.001$ ($p < 0.05$). Variations in drying temperature affect the antioxidant activity of 6162,7008 ppm at a temperature of 90°C. This temperature is the best temperature in the research results of instant yellow rice of Gembili tubers.

ACKNOWLEDGEMENT

Authors would like to deliver the sincerest gratitude to the Indonesian Ministry of Education and Culture's National Achievement Centre (Puspresnas) for the fundings of this activity, as well as to Universitas Muhammadiyah Surakarta (UMS) for the enormous amount of supports and accompaniment during the course of this research. Authors also expresses gratitude to all parties involved for their respective parts in this study.

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p-ISSN: 2477-3328
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