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Benefit of Purple Aruk Rice (Siangu) in Lowering Body Mass Index (BMI) and Body Fat Percentage

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abstract

Aruk rice is an iconic rice from Province of Bangka Belitung which is made from cassava while purple aruk rice (PAR) is made from sweet potato (*Ipomea batatas*). *Ipomea batatas* is a high nutritional food that possesses several medicinal values including anti-cancer, antidiabetic, and anti-inflammatory activities. This research aimed to assest the organoleptic features of PAR and to analyze the effect of PAR consumption in lowering the BMI and bofódy fat percentage. The design of this research was randomized crossover design with quasi experimental research within subjects single-factor two-level design. This experiment consisted of three phases, phase 1 (plain rice consumption), wash out phase, and phase 3 (PAR consumption). The only different between the two phases was the source of the carbohydrate. The data of decreasing BMI and body fat percentage betweern plain rice diet and purple aruk rice were analyzed by using paired t test. The organoleptic assessment showed that the aroma of PAR is dislikeable but the natural purple colour is likeable. The decreasing of BMI and body fat percentage was found higher in phase 2 (2,05±0,10) than phase 1 (0,4±0,14), p=0,002. The decreasing of body fat percentage was also found higher in phase 2 or purple aruk rice diet (2,55±0,25) compared to phase 1 plain rice diet (0,5±0,20), p=0,003. Consumption of aruk purple rice lower BMI and body fat percentage more effective than consumption of plain rice.

1. Introduction

Obesity has been a world public health concern within last twenty years due to its increasing prevalence, particularly in developing countries. The data of Basic Health Research (Riskesdas) showed that the prevalence of obesity in Indonesia was 15,45% in 2013 and increase to 26.6% in 2018. Obesity poses a bad impact to health and might become a risk factor for other degenerative diseases and is associated with the development of life-threatening chronic conditions such as type 2 diabetes mellitus, cardiovascular disease, metabolic syndrome atherosclerosis, heart attack, stroke, and cancer (Lenz and Hamilton, 2004; Must *et al.*, 1999; *Nelson* and Cox, 2008). Obesity is caused by some factors such as the genetic factor, lifestyle, and daily diet. Lifestyle and daily diets are the most dominant factor and possible to control (WHO, 2000). Low physical activity and high-calory diet are the most common factors found in Indonesia. Most of Indonesians consume plain rice as the main source of carbohydrate. The

glycemic index of plain rice is relatively high so glucose resulted in digestion are absorbed into blood immediately.

Sweet potato (*Ipomeas batatas*) is one of the most nutritious plants which is easily found in Indonesia. It is best known for its carbohydrate content so it can be consumed as a carbohydrate source to substitute plain rice. As they contain abundant nutrients, mineral, and functional polyphenols, purple sweet potatoes can be used as a functional food material (Mohanraj and Sivasankar, 2014). The carbohydrate form contained by sweet potato is starch and this starch is resistant to digestion enzyme in the intestine. This physiological effect is similar to fiber that may provide a protection against colon cancer, improve glucose tolerance and insulin sensitivity, repair lipid profile, increase satiety, and reduce fat storage (Helen *et al*., 2013). Polakof *et al*. (2013) reported that resistant starch may reduce fat percentage and restore the inflammation in the liver of obese rats. Beside resistant starch, sweet potato also contains anthocyanin. Anthocyanin is one of the phytochemical compounds that give purple color to plant and is best known as an antioxidant. Antosianin reduces the level of oxidative stress in obese-induced rats (Zhang *et al*., 2015).

Aruk rice (nasi aruk) is an iconic food from Province of Bangka Belitung. Aruk rice was usually consumed to substitute rice because the rice was not evenly distributed during colonialization period. Aruk rice is recently promoted to support food diversity program and to decrease the dependency of rice. The government of Bangka Belitung has obtained the right patent of aruk rice as an iconic local food. Aruk rice is made by using cassava (*Manihot esculenta*), while purple aruk rice is made by using sweet potato (*Ipomea batatas*). Purple aruk rice (in Bahasa means nasi aruk ungu:siangu) This study aims to assesst the organoleptic features of purple aruk rice and analyze the effect of purple aruk rice consumption in lowering the BMI and body fat percentage.

Most obese individuals seek weight loss drugs that give negative side effects such as dizziness, inflammation in the digestive track, liver impairment, and kidney problem. Those drugs are designed to suppress hunger and appetite, block fat absorption, or reduce stomach volume. The result of this study is expected to enrich the information regarding the beneficial effect of purple aruk rice consumption, therefore obese individuals would switch the weight loss management from using chemical drugs to nutritional management consuming purple aruk rice. In the other hand, the food diversity program can succeed and people substitute the plain rice to aruk rice as carbohydrate source.

2. Method

2.1 Making Process of Nasi Aruk

Fresh sweet potatoes were purchased from the traditional market. The sweet potatoes were washed, skinned, and chopped. Chopped sweet potatoes were sunk in a big container for 7 days. This sinking process would cause a strong smell. After 7 days sinking, the sweet potatoes bulk, which is puple colour, were squeezed by using a sack. The dried purple bulks were shaped into grains and dried in 40 ^{o}C.

2.2 Organoleptic Assessment

The organoleptic assessment was carried out after making the process of purple aruk rice had been completed. Twenty amateur panellist were involved in the organoleptic assessment of purple aruk rice. Four features, including texture, aroma, taste, and colour, were assessed in this study. Panellist gave a score (1-7) for all organoleptic features. The scoring description is shown in table 1. Scores that were obtained from 20 panellists for each feature are shown as mean. The higher score obtained, the more likeable the tested product (purple aruk rice).

Table 1 Score description for organoleptic assessment of purple aruk rice

Score	Description
1	Dislike extremely
2	Dislike moderately
3	Dislike slightly
4	Neutral
5	Like slightly
6	Like moderately
7	Like extremely

2.3 Research Design

The subjects of this study are 5 female studens (age 19 years old). They stayed in a dorm during this study to control their diet and activity. Since they are enrolling in the same study program, their daily physical activity is similar. This research was a randomized crossover design or within subjects single factor two-level design. The research subject was also the control subject. This design aims to minimalize the effects of biological factors and time-to-time variation. Therefor every subject was involved in both phases, phase 1 which they consumed plain rice as a carbohydrate source (control) and then phase 2 which they consumed purple aruk rice as a carbohydrate source (treatment). The diet menu for subjects is shown in

the supplementary table. The purple aruk rice was given twice a day (100 gram/serving) with side dishes. Phase 1 and 2 were conducted for 2 weeks. The BMI and body fat percentage were measured before and after all phases. Between phase 1 and 2, washout period was applied during two weeks to restore the metabolism of subjects to basic condition hence the phase 1 effect on the subjects could be removed. During washout period, the subject's diet menu was not under our control. The experimental set up is shown in figure 1.

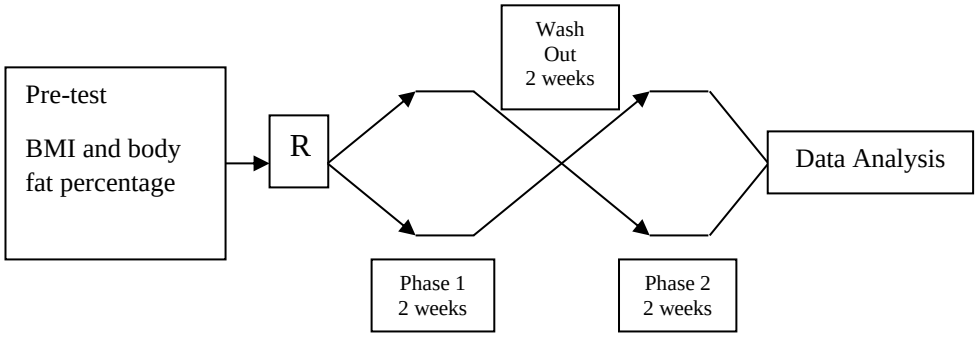


Figure 1. Experimental set up. Phase 1 used plain rice as the carbohydrate source and phase 2 used purple aruk rice as the carbohydrate source**.**

2.4 BMI and Body Fat Percentage Measurement

The measurement of BMI and body fat percentage were carried out by using a body fat monitor tool Omron HBF-306 (Omron Company). The BMI is an International indicator to categorize a person as underweight, normal, overweight, or obesity by quantifying the ammount of tissue mass (Table 2). The BMI can be measured as follows:

$$\frac{Body\ weight\ (kg)}{Body\ height\ (m)^{\ 2}}$$

Table 2 BMI classification

Lean	less than 18.5
Normal	more than 18.5 and less than 25
level 1 obese	more than 25 and less than 30
level 2 obese	more than 30

Body fat percentage refers to the percentage of body fat mass (the weight of the fat) in relation to body weight. The weight that is not fat is referred to as the fat free body mass. Body fat percentage is important to be measured to ensure that the decreasing body weight results from the decreasing of fat mass. Omron Body Fat Monitor measures the body fat percentage by the Bioelectrical Impedance (BI) method. Tissues containing much water such as muscles, blood vessels, and bones are highly conductive with electricity, but fat tissues are not.

Therefore, by using this principle, it is possible to determine the ratio of fat tissue compared to other tissues in the body by measuring the electric resistance of the body tissues,using extremely weak electric current applications to the body. As the electric current applied to the human body during the body fat measurement is extremely weak, of about 50 KHz to 500 µA, one will not feel the electric stimulation, and this method is safe for the human body. Body fat percentage classification shown in table 3.

Table 3 Body fat percentage classification in male and female

Body fat %	**Low**	**Normal**	**Slighty High**	**High**
Male	Less than 10%	10% or more and less than 20%	20% or more and less than 25%	25% or more
Female	Less than 20%	20% or more and less than 30%	30% or more and less than 35%	35% or more

The measurement was carried out in the morning before breakfast as recommended in the guidance book of Omron HBF-306. Personal data of the subjects incuding height and age were set on the device before measurement. The subject should stand with both feet slightly apart. The subjects hold the grip electrode and their arms were kept straight out at a 90 degrees angel to their body. They were not allowed to move during the measurement. While measuring, the bar will increase from the left, 3 bars at a time until a maximum of 12 bars. The bar shows the completion of the measurement. The display will show the measurement result including BMI and body fat percentage. BMI was shown in kg/m2 and body fat percentage was shown in %.

2.5 Statistical Analysis

The data on BMI and body fat percentage are shown in mean±SD. The difference of BMI and body fat percentage between phase 1 (plain rice consumption) and phase 2 (purple aruk rice consumption) were analysed by paired t test and the analysis was carried out by using SPSS 20.

3 Result and Discussion

3.1 Organoleptic Assessment

Organoleptic assessment is an assessment conducted to determine texture, aroma, taste, and appearance of a food product. Organoleptic approaching gives some benefits such as low cost and easy to conduct (Lim, 2011). The affective test was used in this research to determine the

texture, aroma, taste, and colour of purple aruk rice. The organoleptic assessment result of purple aruk rice is shown in Table 1. The data are shown as mean of total scores obtained from 20 panellists.

Table 1 Organoleptic Assessment Result

Organoleptic Items	Score
Texture	4
Aroma	2,75
Taste	4,2
Colour	5,4

The affective test determined the acceptance level by involving expert or amateur panellist. The affective test in this research used hedonic test with scale 1-7. Twenty amateur panellists were involved in the organoleptic assessment of purple aruk rice. Texture and taste items got score 4 and 4,2 respectively. Based on organoleptic score, texture and taste of purple aruk rice were neutral. Appearance of purple aruk rice got the highest score (5,4) and panellists like the natural purple colour. Aroma item got the lowest score (2,75) and it means that panellist did not like the aroma. Strong aroma was produced during the sinking process and the aroma reduced after drying process. Purple aruk rice was made by using traditional method and limited equipment. More sophisticated technology will be needed to process the sweet potato and results in tasty purple aruk rice with homogeny texture and interesting appearance. Handayani *et al*. (2017) reported that rice analog made by using sweet potato is categorized as low amylose rice. Low amylose rice results in good-tasting and smooth texture rice.

3.2 Analysis of Body Mass Index and Body Fat Percentage

The result of research showed that there was a significant decreasing of body mass index (p=0,003) and body fat percentage (p=0,002) after purple aruk rice consumption for 14 days. Phase 1 and phase 2 were applied to subjects during 14 days. The only difference between both phases was the main source of carbohydrate. Phase 1 used plain rice whereas phase 2 used purple aruk rice as the main source of carbohydrate. Figure 2 and 3 show the decreasing of BMI (kg/m^2) and body fat percentage respectively after phase 2 (purple aruk rice treatment). The BMI decrease from 34,025±2,26 to 31,475±2,41 and the body fat percentage decrease from 26,625±21,92 to 24,575±2,03, after 14 weeks of purple aruk rice consumption.

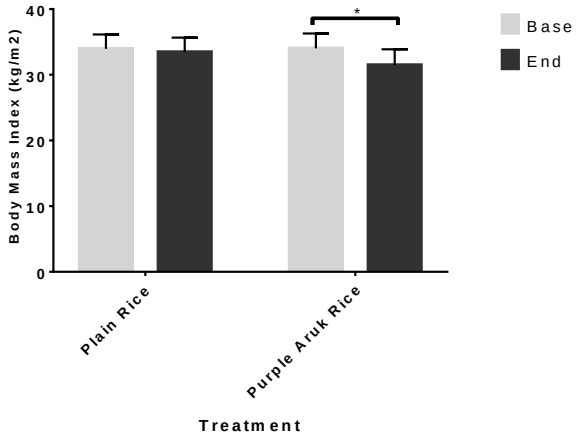


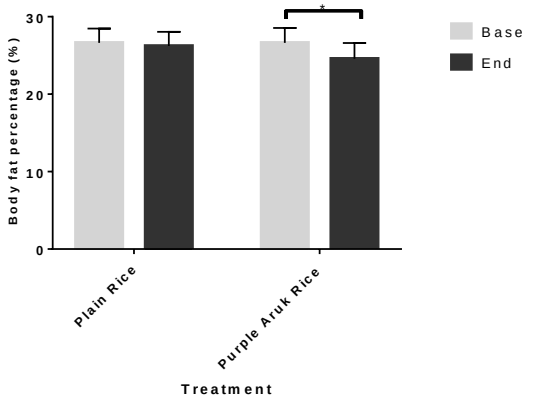
Figure 2 Body mass index (BMI) of subjects before and after the treatments. Data are shown as mean±SD (n=5). In phase 1 (plain rice consumption), there is no difference of BMI after 14 days of treatment. In phase 2 (purple aruk rice consumption), there is a statistically significant decrease in BMI (indicated as asterisk) after 14 days of treatment (p=0,003).

Sweet potato is one of the average calorie starch food and provides 90 calories/100 g. The tuber of sweet potato contains unsaturated fats and is a rich source of dietary fiber, antioxidants, vitamins, and mineral (Monhanraj and Sivasankar, 2014). The resistant starch contained in sweet potato is the main energy that enables it to replace plain rice. Food Security Agency of Bangka Belitung (Badan Ketahanan Pangan Bangka Belitung) reported that energy content of 100 gram of aruk rice (cassava aruk rice) is 353 kcal. Nutritional information of purple aruk rice or siangu has not been analyzed but USDA (2012) reported that nutritional value per 100 g of sweet potato contains 20.1 g carbohydrate, 12.7 g starch, 4.2 g sugar, 3 g dietary fiber, 0.1 g fat, 1.6 g protein, 77 g water, vitamins, and minerals. Several studies repored that consumption pf sweet potato may increase the blood level of vitamin A. Sweet potato contains between 100-1600 μg of retinol activity equivalents (RAE) of vitamin A per 3.5 ounces. These amounts are enough to fulfill 35% of total vitamin A needs (Mohanraj and Sivasankar, 2014).

Ipomea batatas L or sweet potato is best known for its high carbohydrate content. Starch is the predominant form of the carbohydrate and is resistnat to digestion in intestine (Helen *et al*, 2013). The resistant starch is reported to have a similar effect as fibre, its bulk may provide protection against colon cancer (Hylla *et al*, 1998), increase insulin sensitivity, lowers plasma cholesterol, increase satiety, and reduce fat storage. Sweet potato-based diet is beneficial for stomach cancer patient (You *et al*., 1988). Resistant starch may lower BMI by affecting directly the gut hormones and delay hunger. In addition, resistant starch and dietary fibre modulate leptin hormone released by brain so food intake or eating activity may be reduced (Polakof *et*

al., 2013). Bodinham *et al*. (2010) reported that consumption of 48 gram resistant starch may be a benefit for management of metabolic syndrome and appetite. Purple sweet potato reduce weight gaib in obese mice after 12 weeks treatment and also increase energy expenditure. In addition, purple sweet potato ameliorate lipid profile by increasing high density lipoprotein in diet-induced obesity mice (Ju *et al*., 2017).

Figure 3 Body fat percentage (%) of subjects before and after the treatments. Data are shown as mean±SD (n=5).



In phase 1 (plain rice consumption), there is no difference of BMI after 14 days of treatment. In phase 2 (purple aruk rice consumption), there is a statistically significant decrease in BMI (indicated as asterisk) after 14 days of treatment (p=0,002).

Beside the starch content, protein inhibitor-2 (PI-2) that are derived from sweet potato may reduce appetite and food intake by stimulating teh releasing of satiety hormones cholecytokinin (CCK). The presence of PI-2 in the inestine leads to the elevating level of CCK in response to a meal. This hormone acts on various tissues including gastrointestinal tract upon its releasing and lead to the delay of gastric emptying (Begliner *et al*, 2001). Ludvik *et* al (2004) reported that consumption of white sweet potato (caiapo) can reduce the body weight significantly after 2 months. Amylose content raises the blood sugar level slowly and is recommended as a healthy food substance, even for patients with diabetes. Helen *et al*. (2013) also reported that sweet potato extract reduced the BMI and fasting blood glucose level.

The phytochemical compounds of sweet potato are carotenoid and natural phenols (Dini *et al*., 2009; Carvalho *et al*., 2010; Rumbaoa *et al.*, 2009). Anthocyanin is the main phytochemical compound contained in sweet potato. Anthocyanin pigments are responsible for the rich purple tones of the flesh (Monharaj and Sivasankar, 2014). Anthocyanin poses important antioxidant and anti-inflammatory features, particularly when passing through the digestive tract. This compound may lower the potential health risk due to heavy metals and oxygen radicals (Ishida

et al., 2000). Anthocyanin may repair the insulin resistance condition and lipid profile of diabetes patients. Sumardika and Jawi (2012) reported that sweet potato extract may restore lipid profile on rats fed with high-cholesterol diet by increasing the production of superoxide dismutase enzyme (SOD).

Beside anthocyanin, a sweet potato contains a various phytochemical compound that may give health benefit including alkaloid, phenolic compounds, caffeoylquinic acid and derivates, coumarins, triterpens, and furanoterpenoids. These compounds allow the sweet potato to possess various pharmacological properties sucs as anti-obesity, antidiabetes, anti-inflammatory, anti-cancer, and antioxidant activity (Meira *et al*., 2012). Its antioxidant activity enables the sweet potato to lower the potential heath risk caused by free radicals (Huang *et al*., 2004). Phenolic and alkaloids possess several pharmacological features including anti-bacterial, hepatoprotectant, anti-histamine, and other biological effects (Okudaira *et al*., 2003; Islam *et al*., 2003). Coumarins contained in sweet potato, such as aesculetin (Minamikawa *et al*., 1962), scopoletin, and umbelliferon, may possess anti-coagulation properties, HIV replication inhibitory activity, hepatoprotective and antioxidant activity (Cambie and Ferguson, 2003; Kang *et al*., 1998; Shaw *et al*., 2003; oliveira *et al*., 2001; Liu *et al*., 2001).

4. Conclusion

The present study revealed that purple aruk rice consumption gave a beneficial effect on the body. Purple aruk rice consumption to constitute plain rice as a carbohydrate source result in the decreasing of BMI and body fat percentage. Moreover, its rich nutritional content may improve the metabolism and can fulfill the energy demand. Purple aruk rice can be promoted to support food diversity. Appropriate stake holder such as regional government may involve producing purple aruk rice with higher quality.

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