Unlocking Antioxidant Potential: Comparative Analysis of Sembada 188 and Keladi Rice as Functional Ingredients in Novel Food Production

Mas Munira Rambli
Natasha Azamain
Eng-Tong Phuah

Follow this and additional works at: https://ajstd.ubd.edu.bn/journal

Part of the Biotechnology Commons, Engineering Commons, and the Physical Sciences and Mathematics Commons
Unlocking Antioxidant Potential: Comparative Analysis of Sembada 188 and Keladi Rice as Functional Ingredients in Novel Food Production

Mas M. Rambli a,b,*, Natasha Azamain a,b, Eng-Tong Phuah a,b

a School of Applied Sciences and Mathematics, Universiti Teknologi Brunei, Bandar Seri Begawan, Brunei Darussalam
b Centre for Research on Agri-Food Science and Technology, Universiti Teknologi Brunei, Bandar Seri Begawan, Brunei Darussalam

Abstract

Rice (Oryza sativa L.) is an essential crop that is a dietary staple for more than half of the world’s population. There is currently a movement in consumer behaviour toward healthier food consumption, which is fuelling interest in functional diets like coloured rice. Sembada 188 and Keladi rice are underutilised in Brunei Darussalam and are expected to have functional qualities. A comparison of antioxidant properties between Sembada 188 and Keladi rice was performed in this study. This research produced puffed rice treats prepared by steaming rice, washing, drying for 6–8 h at 60 °C, deep frying for 25 s at 180 °C, and then mixing with Nypa fruticans Wurmb sugar. The result showed that Keladi rice has high anti-radical activity with 92.62% RSA detected, which has the potential to be a functional ingredient. Due to high-temperature treatment, the production process has decreased in % RSA in Keladi rice by 6.83%. The addition of Nypa fruticans Wurmb sugar has increased the cumulative antioxidants value in Sembada 188 rice significantly (p < 0.05) by 43.9% whilst significantly (p < 0.05) decreased in Keladi from 92.62% to 85.79%. These findings indicate that the underutilised Keladi and Sembada 188 rice can contribute to antioxidant properties in novel food production.

Keywords: Antioxidants, DPPH assay, Pigmented rice, Product development, Rice

1. Introduction

Rice (Oryza sativa L.) is one of the world’s most important grain crops, considered a dietary staple food for over half of the population globally (Arouna et al., 2021). It contributes to roughly 60–70% of daily calories and one-third of protein requirements. In recent years, there has been a significant shift in consumer behaviour toward healthy food intake because of profound knowledge of health and changing lifestyles and growing concerns with the benefits associated with health and wellness food (Ali & Ali, 2020; Kamaraddi & Prakash, 2015). This can be seen in the increased consumption of pigmented rice, mainly brown rice, due to its functional properties compared to polished white rice. Pigmented rice such as red, brown, purple, and black has been proven to have antioxidants with free radical scavenging effects and bioactive compounds (Nam et al., 2006; Sun et al., 2010; Thuengtung et al., 2018). The bioactive compound anthocyanin is mostly responsible for rice pigments, which possess antioxidant properties. Laokuldilok et al. (2011) found that the major
antioxidants present in pigmented rice are γ-oryzanol and phenolic acids consisting of 39–63% and 33–43%, respectively (Laokuldilok et al., 2011). Rice grains high in anthocyanins have long been known as good sources of natural and safe food colourants. Synthetic colouring may cause adverse and hazardous reactions in humans and the environment, increasing demand for naturally coloured rice, such as purple rice, which has high amounts of anthocyanins. Thus, purple rice not only offers enough anthocyanins to meet the expanding need but also has the potential to raise the value of rice products (Yamuangmorn & Prom-u-Thai, 2021). It has been shown that bioactive compounds such as anthocyanins, cyanidin-3-glucoside, pelargonidin-3-glucoside in coloured rice demonstrated aldose reductase inhibitory effects, implying that they could help in prevention of diabetes. Moreover, another study has reported that consuming anthocyanin rich rice reduced cholesterol, LDL cholesterol, and triacylglycerol concentrations in rats (Yodmanee et al., 2011).

In Brunei Darussalam, there are local polished and pigmented rice variants available in the market that are underutilised. Pigmented rice such as Pusu Merah, Pusu Hitam, and Keladi rice (Oryza sativa L. indica) are often overlooked that can potentially exhibit similar functionalities in delivering beyond the essential nutrients. However, the consumption of pigmented rice is relatively low compared to the intake of polished white rice. This is supported by Galawat and Yabe (2010) in their study, where both urban and rural consumers in Brunei Darussalam are likely to prefer white, long, and organic rice as their staple foods. The result might be due to the higher price and the unfamiliarity with pigmented rice (Galawat & Yabe, 2010). Due to the lower popularity of pigmented rice among Bruneians, there are boundless possibilities that can be further investigated on the usage and incorporation of pigmented rice, especially local variants, into different goods such as puffed rice, biscuits, bread, and the traditional local kuih (Ahmad-Hanis et al., 2012; Galawat & Yabe, 2010). Therefore, the utilization of local pigmented rice as a simple snack food will encourage greater intake, which concurrently brings numerous health benefits and expands the local rice expenditure to full capacity.

2. Materials and methods

2.1. Raw materials

Two Brunei rice varieties; Sembada 188 and Keladi were used in the process of developing a new product. 2 kg of Sembada 188 and Keladi rice was obtained from a local farmer's market at Tutong. Each variety was brought to the food incubator and stored in a dry condition at 23 °C until further analysis. A 500 g palm sugar (Gula Anau) was purchased from a local supermarket and was stored at 4 °C until usage.

2.2. Sample formulation

The ingredients used in this product development are two varieties of Brunei local rice and palm sugar simple syrup. Product formulation was as shown in Table 1.

2.3. Sample preparation

(a) Rice: Cooked rice was prepared by steaming for 15 min at 80 °C. Rice was cooled down and dried in a food dehydrator (Buffalo CD965) at 60 °C for 6–8 h to a moisture content of 13.3%. The sample was stored in a dry and cool place until further analysis.

(b) Puffed rice: The experimental formulation was done by deep frying dried rice in vegetable oil for 25 s at 180 °C until the rice expanded. The puffed rice was strained and let cool. The sample was stored in a dry and cool place until further analysis.

(c) Product development: Puffed rice treats were developed by mixing puffed rice and sugar syrup mixture. Sugar syrup was made using 30 g of palm sugar mixed with 30 g of granulated sugar and 60 ml of water. The mixture was brought to a boil and immediately poured into the puffed rice to create the final product. The puffed rice was pressed down to an 8-inch square mould and cut into 1-inch squares when it was still warm. The procedures were repeated for two rice samples. The product was then cooled on the mould before being packed in an airtight container and stored in a cool and dry place until further analysis.

2.4. Antioxidants analysis

The antioxidant activity of rice samples was determined by in vitro method; 2,2- diphenyl-1-picrylhydrazyl (DPPH) free radical scavenging assay reported previously (Haile et al., 2016). The assay was performed in triplicate and mean values were deliberated.
Sample extraction: Before analysis, solid food samples were extracted to isolate the target compounds by mixing 10 g of sample with 40 ml of 70% methanol. The mixture was placed on a heating plate with a magnetic stirrer for 30 min at 40 °C. The mixture was then filtered through a filter paper to separate the extract from the residue. The extraction was repeated for all six samples. The extracts were stored in an airtight bottle and kept at 4 °C until further analysis.

Ascorbic acid preparation: Ascorbic acid was used as the reference standard to indicate the positive control in the DPPH assay. A stock solution was prepared by weighing 0.01 g of solid ascorbic acid into 10 ml of methanol to create a 1000 ppm ascorbic acid solution. Different concentrations from this stock solution were prepared by diluting different volumes of solvent into a vial. A control sample was prepared by mixing 1 ml of 70% methanol with 2 ml of DPPH methanolic solution. The vials were then incubated in the dark for 30 min to allow the reaction to occur. The absorbance was measured at 517 nm using UV-VIS Spectrophotometer, and a standard curve was plotted.

DPPH antioxidants: A solid DPPH of 4 mg was mixed with 100 ml of methanol in a flask. Due to the sensitivity to light, the flask was wrapped with aluminium foil and the preparation room was also ensured to have minimal light passing through. 1 ml of each sample extract was mixed with 2 ml of DPPH methanolic solution into a vial using a micropipette. The steps were repeated for each sample extract. A control sample was also prepared by mixing 1 ml of 70% methanol with 2 ml of DPPH methanolic solution. The vials were then incubated in the dark for 30 min to allow the reaction to occur. The absorbance of the mixtures was read at the value of 517 nm using a UV-VIS Spectrophotometer. The presence of a radical scavenging compound can be evaluated by the change in colour from deep violet to yellow which indicates that the compound is reduced. The DPPH radical scavenging activity was calculated using the following equation:

\[
\text{RSA}\% = \left(\frac{A_{\text{control}} - A_{\text{sample}}}{A_{\text{control}}}\right) \times 100
\]

2.5. Statistical analysis

Values obtained from antioxidant analysis were statistically analysed using GraphPad Prism Version 9. Results were expressed as mean ± SD.

3. Results and discussion

3.1. Standard graph of ascorbic acid

The Antioxidant activity of the rice methanolic extract was determined through the Ascorbic acid equivalent. The standard curve of Ascorbic acid inhibition is illustrated in Fig. 1. The graph was plotted between the RSA (%) and the concentration of ascorbic acid.
3.2. DPPH radical scavenging activity

DPPH is a stable free radical, and once it encounters a proton-radical scavenger such as an antioxidant compound or a radical species, the maximal absorbance at 517 nm will disappear rapidly. A distinct colour changes from purple to yellow can be seen (Laokuldilok et al., 2011). The radical scavenging activity (RSA) of all sample extracts was assessed and expressed in percentage. Table 2 shows that RSA ranged from 41.74% to 92.62%. The highest radical activity was found in the KR extract (92.62%) and the lowest was in the SR extract (41.74%). The order of antiradical activity was KR > KPR > KPRT > SPRT > SPR > SR.

3.3. Antioxidants in pigmented rice

In general, pigmented rice samples had higher DPPH RSA than polished rice samples. This is because purple rice contains anthocyanins, specifically cyanidin 3-O-glucoside and peonidin 3-O-glucoside (Kushwaha, 2016; Laokuldilok et al., 2011). According to Salgado et al. (2010) and Kang et al. (2013), black rice has higher anthocyanin content and higher free radical scavenging activities, as well as higher phenolic and flavonoid contents than polished rice (Kang et al., 2013; Salgado et al., 2010). A similar study by Ghasemzadeh et al. (2018) demonstrated a favourable association between DPPH RSA and the colour of rice bran, with black rice extract having the highest antioxidant activity compared to red and brown rice extracts. Black rice has been discovered to have higher quantities of flavonoids, phenolic acids, and anthocyanins, all of which contribute to the DPPH RSA (Ghasemzadeh et al., 2018). These bioactive chemicals have been associated to disease risk reduction and biomarkers for diseases such as type 2 diabetes, cardiovascular disease, and cancer (Kalt et al., 2020). As a result, the rice samples used in this study have the potential to be a functional ingredient or food.

3.4. Effect of puffing on antioxidant activity

According to Fig. 2 above, the puffing process of Sembada 188 rice by deep-frying has shown a significant (p < 0.05) increase in antioxidant activity from 41.74% to 84.93%. However, this result was in contrast with the findings by Kushwaha (2016), who observed a significant loss of anthocyanin in cooked rice by 74.2% compared to raw rice. It could be speculated that the DPPH RSA in SPR could be attributed to the oil used during frying. The addition of kel sugar to blank SPR has shown a significant difference (p < 0.05) in the % RSA of the sample. According to Srikaeo et al. (2018), nipa palm sugar proves to have a high antioxidant activity that could contribute to DPPH RSA in the sample (Srikaeo et al., 2018). In contrast, RSA % of Keladi rice slightly decreased from the puffing process to the addition of Nypa fruticans Wurmb sugar. The value perceived declined from 92.62% to 91.53% and then to 85.79%, as seen in Fig. 2. Similar results were observed from other findings where the loss of anthocyanin contributed significantly to the high-temperature treatment (Kushwaha, 2016). This is due to anthocyanin undergoing a series of mechanisms such as glycosylation, nucleophilic attack of water, cleavage, and polymerisation (Rodriguez-Amaya, 2019). However, even with extreme heat exposure, the samples prepared still have an excellent scavenging effect on DPPH-radicals. This suggests that the high antioxidative property associated with the samples mentioned might result from other antioxidative compounds besides anthocyanin.

4. Conclusion

The antioxidants of two rice varieties in Brunei have been studied. This study has shown that Keladi and Sembada 188 rice has the potential to be a functional ingredient due to its high antioxidant...
activity. The effect of puffing with high-temperature treatment has decreased in RSA due to the loss of anthocyanin in the rice. The combination of nipa palm sugar and puffed rice has shown significantly (p < 0.05) improved antioxidant properties as well as providing a crispy texture in the puffed rice treats developed. In summary, the study presents an innovative puffed rice snack that not only offers enhanced nutritional value but also aligns with contemporary preferences. Furthermore, by utilizing locally grown rice in Brunei, this development promotes the utilization of domestic agricultural resources, contributing to both dietary diversity and economic value.

Authors’ contributions
The authors contributed to the manuscript equally.

Conflicts of interest
All authors declare no competing interests.

Acknowledgement
The authors gratefully acknowledge the financial support from UTB Funding (Project no. UTB/GSR/2/2023(9)).

References


