# Physicochemical And Antioxidant Properties Of Red Rice Varieties Of Wakawondu And Wangkariri From North Buton, Indonesia

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**ABSTRACT**: Wakawondu and Wangkariri varieties of red rice are consumed by the community as a source of carbohydrates. The red pigment of rice shows a high anthocyanin content,which has a high potential for development. The proximate and antioxidant characteristics of the two cultivars did not show significant differences. Both rice cultivars had different pasting characteristics (peak viscosity, troughviscosity, breakdownviscosity, setback viscosity, final viscosity).The pasting properties of Wangkariri cultivar rice were 50% higher than Wakawondu cultivar on all pasting variables. These results indicate that both cultivars should be applied to different food products.

**Index Terms:** Wakawondu, Wangkariri, pasting properties, antioxidant, Buton.

## 1. INTRODUCTION

Rice is a staple food along with tubers and sago for Indonesians. Approximately 60-70% of Asians depend on rice as a source of calories (Lin et al., 2011). In addition, rice is also a source of protein, vitamins, and minerals that are beneficial for health. However, rice is blamed for several diseases such as diabetes mellitus (McKeown et al., 2002; Hu et al., 2003) as the types of rice widely consumed have a high glycemic index (Rohman et al., 2014). North Buton is one of the areas in Southeast Sulawesi that focuses on the development or local upland rice cultivation (Sadimantara and Muhidin, 2012). There are 22 cultivars in the area, namely (1) Wakombe Cultivars, (2) Wabalongka Cultivars, (3) Warumbia Red Cultivars, (4) Patirangga Cultivars, (5) Apolo Cultivars, (6) Kasakabari Cultivars, (7) Wangkaluku Cultivars, (8) Wangkariri Cultivars, (9) Warangka Cultivars, (10) Wabila Kambowa Cultivars, (11) Wakawondu Cultivars, (12) Wajini Cultivars, (13) Wawonii Cultivars, (14) Mantebeka Cultivars, (15) Cultivators Wampogeru, ( 16) Cultivar Wabila Lambale, (17) Warumbia White Cultivar, (18) Waburiburi Cultivar, (19) WararaCultivar, (20) WangkatemaCultivar, (21) Warema Cultivar,and (22) Watanta Cultivar (Sadimantara and Muhidin, 2012). Wakawondu and Wangkariri cultivars are widely cultivated by farmers and traded as unique local red rice. Genetic diversity and environmental factors are responsible for variations in local rice characteristics (Singh et al. 2005; Kesarwani et al. 2013). The red color of the rice shows that the functional compounds contained are anthocyanin, which has long been known to play a role in the prevention of coronary heart disease, diabetes, and hypertension (Hariadi et al., 2018). Therefore, it is important to characterize both cultivars to support their cultivation and economic valueusing proximate, pasting, and antioxidant analysis to obtain a comprehensive characterization.


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## 2 Materials and Methods

### 2.1 Material

The main materials of this study were red rice varieties of Wakawondu and Wangkariri from North Buton, Indonesia. Other materials used include ethanol (Merck, ≥99%), NaOH (Merck, ≥99%), DPPH (Sigma), HCl (Merck, ≥37%), $Na_2S_2O_3$, $Na_2SO_4$ (Sigma, ≥99.0%), acid acetate, iodine, $KIO_3$, KOH, thymol blue, selenium, $H_2SO_4$, Phenolphthalein, $H_3BO_3$, Bromine Cresol Green, n-hexane (Merck, ≥99%), Ethyl acetate, and $CHCl_3$.

### 2.2 Moisture, lipid and ash contents

Determination of moisture, lipid and ash content were done based on the method used by Sudarmadji (2003).

### 2.3 Potein content (Micro-Kjeldhal)

One gram of rice flour was put in the 100 mL Kjeldahl flask and 10 mL of concentrated $H_2SO_4$ and 5 g of $Na_2SO_4$ were added. Then the destruction process was done in the fume hood until the entire mixture became a clear liquid. The destruction results were diluted 10 ml using distilled water and 35 ml $NaOH\text{-}Na_2S_2O_3$. The distillate was stored in 100 mL Erlenmeyer Flask containing 25 mL of saturated solution of boric acid and a few drops of indicator. Distillation was stopped after the color changed from pink to green. The solution obtained was titrated with standard 0.02 M HCl (Sudarmadji et al., 1997). The protein content (PC) was extracted with the following equation (1).

$$PC(\%) = (\text{mL HCl} \,.\, \text{M HCl} \,.\, 14.008 \,.\, 5.95 \,/\text{sample mass (g)}) \,.100\% \quad (1)$$

### 2.4 Crude fibre content

A total of 3 grams of rice flour was put into a 500 mL Erlenmeyer Flask, added 50 mL of 1.25% $H_2SO_4$ solution and then boiled for 30 minutes with an upright cooler. Then, 50 mL of 3.25% NaOH was added and boiled again for 30 minutes.

After the heating process was finished, it was filtered immediately with a Buchner funnel containing dried filter paper and the mass was noted. The sedimentation was washed sequentially on filter papers with 1.25% $H_2SO_4$, heat, hot water, and 96% ethanol. The filter paper was lifted along with its contents, put into the weighing box (the box's weight was known), dried at a temperature of 105°C, cooled in the desiccator,and finally,it was weighed until the fixed weight (Sudarmadji et al., 1997). Crude fiber content (CFC) was calculated by the following equation (2).

$$\mathrm{CFC}(\%) = ((\text{Filter paper mass} + \text{fibre}) - (\text{Filter paper mass}) / \text{Sample mass}).100\% \quad (2)$$

### 2.5 Pasting properties analysis

Analysis of pasting properties was done using the Rapid Visco Analyzer (RVA, Newport Scientific Warriewood, Australia). Two grams of rice flour added 25 mL of distilled water then the suspension was heated at 50°C for 1 minute. The heating suspension was carried out at a temperature of 50 – 95 °C with an increase in temperature rate of 12 °C/minute. After reaching 95 °C, the temperature was maintained for 20 minutes, then it was lowered again to 50°C and kept for 20 minutes (Pukkahuta and Varavinit, 2008; Olayinka et al., 2008). Information obtained from the analysis of pasting properties including pasting temperature (°C), peak viscosity (RVU), trough viscosity (RVU) at 95°C for 20 minutes, breakdown viscosity (RVU) at 50 °C, and setback viscosity (RVU) at 50 °C for 20 minutes.

### 2.6 Antioxidant activity

The antioxidant analysis started with making a solution by weighing 1 mg of DPPH and then dissolving it in 50 mL methanol. Each test solution was pipetted 3.0 mL then added 1.0 mL DPPH solution, incubated for 30 minutes (for negative control the sample solution was replaced with methanol). After 30 minutes, the color changes were observed. Absorption of each solution was measured using a spectrophotometer at a wavelength of 516 nm. The experiment was conducted three times. Antioxidant activity was expressed in %-inhibition (I) determined by the following equation (3).

$$\mathrm{I}\,(\%) = (\text{Control absorption} - \text{Sample absorption}/\text{Control absorption}).100\% \quad (3)$$

## 3 Results adn Discussion

### 3.1 Chemical contents

Rice is an important source of carbohydrates in Indonesia, complemented by tubers and other cereals. Various rice cultivars have been developed to meet basic human needs, especially in the Asian region. Around 2 billion people in Asia obtain 60 – 70% carbohydrate needs from various cultivars of rice or derivative products (Linn et al., 2011). The Indonesian people rely on rice as the main calorie source, although in some regions they use corn, sago, and tubers as staple foods. North Buton is an area located on Buton Island which has long developed 20 red rice cultivars (Sadimantara and Muhidin, 2012). Wakawondu and Wangkariri cultivars are the most widely traded cultivars.Thus, it is essential to know their physicochemical characteristics, including the proximate analysis results as shown in Table 1.

***Table 1*** *Proximate analysis of red rice varieties of Wakawondu and Wangkariri.*

| No | Parameter | Wakawondu (%) | Wangkariri (%) |
|---|---|---|---|
| 1 | Moisture | 8.95 ± 0.06 | 8.99 ± 0.23 |
| 2 | Protein | 3.68 ± 0.03 | 2.68 ± 0.03 |
| 3 | Lipid | 0.39 ± 0.03 | 0.47 ± 0.04 |
| 4 | Ash | 1.15 ± 0.01 | 1.07 ± 0.06 |
| 5 | Fibre | 2.52 ± 0.03 | 2.03 ± 0.07 |

As can be seen in Table 1, the chemical compositions of the two cultivars are similar. There were no data that show a significant difference in both cultivars. The protein content in rice will affect the rice texture produced (Ishima et al., 1984). Rice with high protein levels usually less tender (hard). In addition, the protein together with the gelatinization temperature also affects the cooking time. Rice with a higher protein content requires more water and longer cooking time. Juliano (1971) explains that rice has approximately 7% protein. Rice with a protein level smaller than 8.5% tends to be fluffier, which is influenced by the polarity nature of the protein to water. Rice protein inhibits water absorption and the development of starch granules when it is cooked; thus limiting the ability to form gelatinization optimally. The calculation results show that the protein content of Wakawondu and Wankariri red rice ranged from 2.68 to 3.58. Wakawondu had the highest protein content of 3.56% while Wankariri rice has a lower protein content of 2.68%. This means that Wakawondu and Wankariri are silken rice. However, Wakawondu requires more water and longer cooking time than Wankariri because the protein layer coats starch granules and protein granules fill the spaces between starch granules in the endosperm. Gealy and Bryant (2009) reported the content of red rice protein in North America varied from 9.9% to 14.0%. Meanwhile, Sompong et al (2011) reported that a number of red rice varieties in the regions of Thailand, Sri Lanka and China contained proteins varied from 7.16% to 10.36%. Protein levels in red rice are relatively higher than in normal white rice, although the rice undergoes a minimal grinding process (red rice). Heinemann et al (2005) reported that red rice in Brazil contained 7.42% protein and white rice contained only 5.71% protein. Another study was also reported by Puwastien et al (2009) which showed that red rice in Thailand contained a protein of 7.92%. Table 1 shows that the crude fat content of the red rice of the Wakawondu variety (0.35%) was smaller than the Wankariri variety (0.43%). Dendy (2005) reported that fat in rice concentrated on the skin layer, which contributed 20% of the mass of rice. In red rice, 51% of crude oil is found in germ, 32% in the layer, and only 17% in the endosperm. In endosperm of the rice grain, lipids are unevenly distributed with the highest percentage is found in outer layers and decreasing progressively towards the center of the grain (Dendy, 2005). Different results were reported by Yoshida et al. (2010),where the fat content of red rice and black rice found in Japan were higher at 2.2% - 3.7%. Meanwhile, Gealy and Bryant (2009) reported that the fat content of rice varieties in North America is 2.4%. Charoenthaikij et al. (2012) reported that the lipid content in red rice flour ranged from 2.65% to 3.24%, whereas Mir et al. (2016) reported in the range of 2.38 – 2.84%. Lipids in Wakawondu and Wangkariri rice are internal components in starch (Hizukuri, 1996). Protein and lipid contentsaffect pasting properties and starch gelatinization (BeMiller and Whistle, 2009). Visually, rice has 4 types of colors throughout the world, namely white rice, red rice, red rice, and black rice. Comparing the chemical composition of the same type of rice originating from different regions will provide a varied chemical composition. This difference is caused by varieties, soil, and environment. Even the difference in processing the rice grain will produce a significant difference. The functional properties of rice are generally found in the skin and epidermis of rice. Lamberts et al (2007) reported that due to the grinding process, there would be a loss of protein and total minerals reaching 28.6% and 84.7%, respectively. Various important minerals are found in hulls such as iron (Fe), zinc (Zn), potassium (K), phosphorus (P), manganese (Mn), and calcium (Ca) (Sperotto et al., 2012).

### 3.2 Antioxidant activity

The functional properties of antioxidants in foods are now being widely campaigned as epidemiological studies result show that the low incidence of certain chronic diseases in rice-consuming regions of the world might be associated with the antioxidant compound contents of rice (Anderson, 2003; Chotimarkorn et. al. 2008). Free radicals that attack the body can originate from the body itself due to metabolic effects as well as from environmental exposure. The molecules with antioxidant activities contained in rice include phenolic acids, flavonoids, anthocyanin, proanthocyanidins, tocopherols, tocotrienols, γ-oryzanol, and phytic acid (Goufo & Trindade, 2014). North Buton Area – Southeast Sulawesi is an area that develops 20 local red rice cultivars that are in great demand by tourists. Among them, Wakawondu and Wangkariri cultivars are the most widely sought. Rice in this area is red rice that is rich in anthocyanin. The main anthocyanin components of red rice are identified as cyanidin-3-glucoside and peonidin-3-glucoside.These compounds have prominent antioxidant activity (Hu et al. 2003; Zhu et al. 2010). The antioxidant activities of Wakawondu and Wangkariri rice are shown in Table 2.

**Table 2** *Antioxidant activity of red rice varieties of Wakawondu and Wangkariri*.

| Concentration (ppm) | Wangkariri | | Wakawondu | |
|---|---|---|---|---|
| | Ethanol extract | Ethyl acetate extract | Ethanol extract | Ethyl acetate extract |
| | Antioxidant activity (%) | | | |
| 300 | 85.657 | 84.728 | 81.142 | 81.673 |
| 200 | 70.120 | 71.315 | 69.987 | 68.526 |
| 100 | 61.620 | 63.479 | 58.167 | 58.167 |
| 50 | 55.511 | 54.714 | 47.145 | 42.098 |
| 20 | 43.559 | 35.591 | 40.903 | 38.645 |
| $IC_{50}$ | 34.87 | 54.16 | 66.76 | 83.10 |

Table 2 shows that Wangkariri cultivars had higher antioxidant activity than Wakawondu cultivars. DPPH radical reduction percentage reached 80% at a concentration of 300 ppm. The high concentration of extract indicated that the damping capacity was categorized as being medium. This could be caused by many anthocyanin pigments in rice cells which were lost due to processing. Processing grain into rice using a grinding tool causes a thin layer of pigment to undergo mechanical degradation. Therefore, to produce red rice with quality pigments, more modern processing is neededas most of the phytochemical components in rice grains are found in the fraction of bran or epidermis. In addition to phytochemicals, red rice contains dietary fiber which supports digestive and cardiovascular health (Champagne et al. 2004). Kimi et al (2012) explain that phenolic compounds play a major role in the antioxidant properties of red rice. Cyanidin-3-glucoside and peonidin-3-glucoside are compounds identified as antioxidant components (Zhu et al. 2010). Mir et al (2016) reported strong antioxidant activity in red rice, with a total phenolic of 0.81 – 1.64 mg equivalent of gallic acid/g, flavonoids 50.67 – 9.41 μg catechins eq/g. White, red, and black rice contains acidic phenolic and anthocyanin compounds in endosperms, embryos, and rice bran (Shao et al., 2014). However, red and black rice ishighly recommended as a source of food rich in antioxidants and fiber.

### 3.3 Pasting properties

Analysis of pasting properties of rice was carried out using a Rapid Visco Analyzer (RVA), a viscometer equipped with a heating and cooling system to measure starch resistance in controlled stirring. Pasting properties showed changes in viscosity during the heating suspension and changes in the physical and chemical properties of starch (Figure 1). Pasting analysis was done to predict the functional properties of rice and its potential applications as food products (Klein et al., 2013). Data from pasting analysis of Wangkariri and Wakawondu cultivar rice are shown in Table 3.

***Table 3** Pasting properties of red rice flour varieties of Wakawondu dan Wangkariri.*

| Properties | Varieties | |
|---|---|---|
| | Wangkariri | Wakawondu |
| Pasting Temperature (°C) | 73.95 | 72.45 |
| Peak Viscosity | 2369 | 1037 |
| Trough Viscosity | 1738 | 914 |
| Breakdown Viscosity | 631 | 123 |
| Setback Viscosity | 533 | 252 |
| Final Viscosity | 2271 | 1166 |

The pasting profile shown in Table 3 includes pasting temperature, peak viscosity, viscosity at 95°C (trough or holding strength), viscosity at constant 95°C (breakdown), viscosity at constant 50°C (setback), and viscosity at 50°C (final viscosity). The results show that all components of the viscosity and temperature of pasting rice flour Wangkariri cultivars were higher than Wakawondu cultivars. Pasting temperature (PT) of Wangkariri cultivar was higher than Wakawondu cultivar. PT shows the starch resistance from structural rearrangement during cooking (Kang et al., 2011). The resistant properties of starch are related to the amylose content of rice. The higher the amylose content, the higher the PT. PT increase indicates polymer chain regularity due to strong interactions in amylose-amylose, amylose-amylopectin, amylopectin-amylopectin and amylose-fat chains (Gunaratne & Hoover, 2002 & Waduge et al., 2006). When the starch is heated, the starch granules absorb a certain amount of water and cause the starch granules to expand;thus, increasing the viscosity. The initial temperature when increasing viscosity is called the pasting temperature. Pasting temperature indicates the minimum temperature of starch for gelatinization. When the development of the granule continues, the starch viscosity rapidly increases. Peak viscosity occurs when the starch granule continues to expand and finally breaks so that the amylose molecule comes out. As can be seen in Table 3, Wangkariri cultivar has a larger size of starch granules than

Wakawondu starch granules. Therefore, a high PV shows great swelling power. The temperature increasewhich continues up to 95°C for a certain period of time reduces the viscosity of the paste (Wahyuni et al., 2017). The ability of starch to bind water to reach the maximum peak viscosity is related to the particle size of starch granules. The larger the size of the granule, the more water that can be absorbed and requires a relatively long time to reach PV (Wahyuni et al., 2016). Different starch crystalline structures give different pasting properties. The viscosity produced by the crystalline structure is called the peak viscosity. Meanwhile, the amorphous structure produceda trough viscosity (TV) (Sankhon et al., 2014). PV and TV difference are called a breakdown viscosity (BV). The greater the BV, the more susceptible the starch to heat changes. Table 3 shows that the BV of Wakawondu was lower than Wangkariri. This means that the crystalline area in the Wakawondu was larger so that it is more resistant to changes in viscosity during heating at 95°C. The setback viscosity, or commonly known as the reverse viscosity, is the viscosity of the paste at 50°C with a duration of 20 minutes illustrating retrogradation of starch molecules in the cooling process. The high setback viscosity value shows the better ability of Wangkariri starch to form a gel than Wakawondu. However, applications in certain food products are not expected to have high viscosity values because they become hardwhen cold. The final increase in viscosity was also observed in this study.The increase of HMT water content also increased the final viscosity. The high final viscosity of starch indicates the ability of starch to form a thickpaste. This property is directly related to gel strength, where Wangkariri starch has greater gel strength than Wakawondu. Setback viscosity (SV) indicates the potential for gel formation and retrogradation tendency. The low BV value of Wakawondu rice starch indicates that the starch is more resistant to heating and stirring than Wangkariri starch. The SV value of Wakawondu rice starch was also lower, indicating that the rice starch gel had a lower hardness. Starch with a low retrogradation tendency indicates the ability to maintain texture during storage (Copeland et al., 2009). In conclusion,the Wakawondu cultivar is more suitable to be applied in making various products because it has physical properties that would be liked by the panelists. Even so, Wangkariri cultivar can be applied to products that require more rigid properties when stored such as vermicelli.

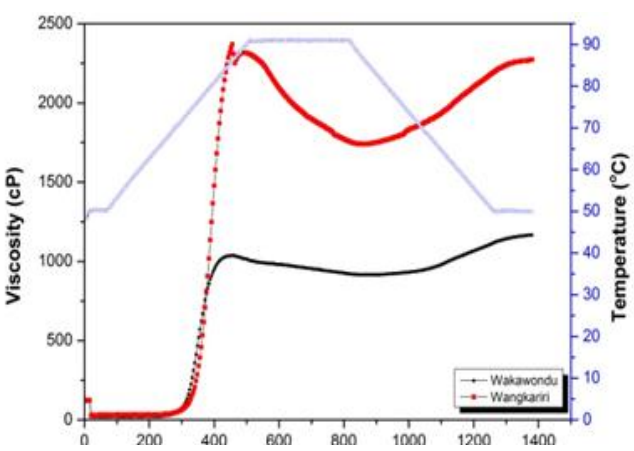


***Fig. 1:** Rapid Visco-Analyser pasting profiles of red rice varieties of Wakawondu and Wangkariri.*

## 4 Conclusion

Wakawondu and Wangkariri rice cultivars have unique characteristics, especially in their pasting properties. The pasting value of Wangkriri cultivars was 50% greater than Wakawondu cultivars. This result can become a reference for the application of both cultivars to produce various products. The variables that determine the application of rice from both cultivarsis the setback viscosity. The setback viscosity of Wakawondu rice was half of Wangkariri rice.

## 5 Acknowledgement

The authors acknowledge to the research institutions and community service (LPPM), Halu Oleo University for financial support under “PENELITIAN DOSEN PEMULA 2017 ($1746^2$/UN29.20/PPM/2017)” grant research.

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