The Differences of Nutritional Composition and Antioxidant Activity between Plain and Black Rice Bran-fortified Goat Milk Yogurt

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Abstract. Yogurt is one of the health-functional superfoods that obtained from milk fermentation. Goat milk yogurt provides an excellent healthy value due to high nutritional composition and bioactive peptides. Rice bran is a nutrient-rich by-product that has been used as livestock feed and pet food. Black rice bran has good nutritional values, high phenolic and bioactive compounds. Bioactive compound has beneficial in human and animal health, such as antioxidant activity. Considering those health benefits, this study aimed to evaluate the difference of nutritional composition (protein, fat, water, ash, and carbohydrate content) and antioxidant activity between plain and black rice bran-fortified goat milk yogurt. This study used Completed Randomized Design (CRD) with a single treatment factor and 3 repetitions. Nutritional value was obtained by proximate analysis and the antioxidant activity was evaluated with the 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging activity. The average nutritional values of plain goat milk yogurt was 2.65% protein, 7.51% fat, 84.62% water, 0.81% ash, and 4.41% carbohydrate while the average nutritional value of black rice bran-fortified goat milk yogurt was 3.42% protein, 6.03% fat, 81.99% water, 0.88% ash, and 7.68% carbohydrate. The average antioxidant activity value in plain goat milk yogurt was 593.72 mg/ml while the average antioxidant activity value for black rice bran-fortified goat milk yogurt was 382.71 mg/ml. The results showed that there were differences in nutritional composition between those two types of yogurt, and black rice bran-fortified goat milk yogurt had higher antioxidant activity.

Keywords: antioxidant, black rice bran, goat milk, proximate analysis, yogurt

1. Introduction

Goat milk has many beneficial effects on human health. The composition of goat milk varies depends on several factors including diet, breed, individuals, parity, season, feeding, environmental management, and health status. Goat milk has higher protein content, vitamin A and B content, free amino acid Taurine, and a considerable amount of minerals, such as calcium and phosphorous. Goat milk is more suitable for those who suffer from lactose intolerance because of its low lactose content [1]. Furthermore, it has better digestibility, alkalinity, greater buffering capacity, and many therapeutic values.
Production of processed products derived from goat milk has grown in recent years. Yogurt is one of the health-functional superfoods that obtained from milk fermentation using Lactic Acid Bacteria (LABs) cultures. The nutritional and healthy values of fermented milk were well-described [2]. Goat milk yogurt is an excellent source of fatty acids, protein, and minerals [3]. Fermentation can enhance the antioxidant activity of milk and dairy products due to sulfur-containing amino acids, phosphate, vitamin A, carotenoids, superoxide dismutase, catalase, glutathione peroxidase, and peptides formation during the process [4]. Fermented goat milk yogurt has antioxidative, antiatherogenic, anti-cell proliferation effect [5][6][7]. It was stimulating the mucosal immune system and improving the defense against intestinal and respiratory infection [8].

Consumption of whole grain and their product increase nowadays. It is associated with many health benefits in part to the unique phytochemical, that it can reduce the risk of developing a major chronic disease such as type II diabetes, obesity, and cancer [9]. The whole grain phytochemicals include carotenoids, phenolics, and vitamin E. Whole grain phenolics have potent antioxidant activity and can scavenge free radicals. Free radicals may increase oxidative stress and cause large biological molecules to damage [10].

Rice (Oryza sativa) is one of the most important cereal crops in the world. By-products from the processing of rice are considered as valuable products. Among other cereal by-products, rice bran is an excellent source of protein, lipid, fiber, and phytosterols. Black rice bran has the highest phenolic compound, and other bioactive compounds such as γ-oryzanol, α-tocopherol, and γ-tocopherol in comparison with RD6 and red rice [11]. γ-oryzanol was a potent antioxidant, chemopreventive, anti-inflammatory, and lipid-lowering[12].

The current study has been carried out on the fortification of goat milk yogurt with black rice bran; therefore it aimed to evaluate the difference of nutritional value (protein, fat, water, ash, and carbohydrate) and antioxidant activity between plain and black rice bran-fortified goat milk yogurt.

2. Research Method
2.1. Yogurt production
Yogurt production has started with the making of working mother culture, by adding 0.35 gram of Lactobacillus bulgaricus, Streptococcus thermophilus, and Lactobacillus acidophilus starter powder (Yogourmet®, Lyo-SAN INC: 500 Aeroparc, C.P. 589, and Lachute, QC. Canada, J8H, 464) into 70 mL pasteurized goat milk and incubated at 45°C for 4 hours until its pH reached 4.5±0.1. Plain yogurt was made by inoculating aliquot of working mother culture (3%) into well-pasteurized goat milk and incubated at 45°C for 4 hours until its pH reached 4.5±0.1. Black rice bran-fortified yogurt was made by adding 3% of working mother culture and 4% black rice bran flour into 480mL well-pasteurized milk and incubated in 45°C for 4 hours until its pH reached 4.5±0.1.

2.2. Proximate analysis
Nutritional value analysis on plain and black rice bran-fortified yogurt based on food and beverage testing of SNI 01-2891-1992, where protein analysis has done with Kjeldahl method, Weibull method for lipid, thermogravimetric method for ash and water, and carbohydrate has been counted with the following equation [carbohydrate content (%) = 100% - % (water content + ash content + protein content + lipid content)].

2.3. Antioxidant activity test
The study on antioxidant activity of plain and black rice bran-fortified yogurt was evaluated through 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging activity [13]. Absorbance value and solution concentration testing was made into a linear regression curve and the equation was required to obtain IC50 value. It is a parameter of antioxidant activity measured by the regression equation.

2.4. Data analysis
The data was processed and analyzed by Microsoft Excel 2010 software. Data was presented in tables and graphic which showed the average value of the 3 repetitions of each treatment.
3. Results

The average nutritional value of plain and black rice bran yogurt, i.e. protein, fat, water, ash, and carbohydrate is presented in Table 1.

| Nutritional Composition | Plain Yogurt | Average of Nutritional Value (%) | Black Rice Bran-Fortified Yogurt |
|-------------------------|--------------|----------------------------------|---------------------------------|
| Protein                 | 2.65         | 3.42                             |                                 |
| Fat                     | 7.51         | 6.03                             |                                 |
| Water                   | 84.62        | 81.99                            |                                 |
| Ash                     | 0.81         | 0.88                             |                                 |
| Carbohydrate            | 4.41         | 7.68                             |                                 |

Based on the proximate analysis (Table 1), black rice bran-fortified goat milk yogurt had higher protein, ash, and carbohydrate content and lower fat and water content. It showed that goat milk yogurt fortified with black rice bran was causing a difference in nutritional composition compared to plain yogurt. The fermentation of goat milk fortified with black rice bran was increasing protein, ash and carbohydrate content (3.42; 0.88; 7.68%). Rice bran has a nutritious mixture of protein, fat, carbohydrate, ash, fiber, and a variety of bioactive compounds [11]. Decreasing water content was caused by the addition of dry matter (black rice bran flour) into the yogurt. The natural ingredient addition or modification of goat milk yogurt has changed its nutritional composition and characterization [14][15].

Black rice bran-fortified goat milk yogurt had higher antioxidant activity (382.71 mg/mL) than plain yoghurt (593.72 mg/mL) (Figure 1). According to [16], the lower the value, the stronger the antioxidant activity. A compound is considered to be very strong antioxidant if IC50 value < 50 µg/mL; strong if IC50 value 50-100 µg/mL; moderate if IC50 value 250-500 µg/mL; weak if IC50 value > 500 µg/mL[16]. Both of those type of yogurt was considered as very strong antioxidant.

![Antioxidant activity](image)

**Figure 1.** Average Value of Antioxidant Activity

Goat milk itself has high protein content, vitamins A and B, free amino acid taurine, and a considerable amount of mineral [3]. Lactic acid bacteria (LABs) fermentation of goat milk has been known as a source of bioactive peptides and amino acids that are beneficial for health. [17] has proved that ginger rhizome goat milk yogurt had the highest antioxidant activities compared to ginger extract cow milk yogurt. The addition of herbal compounds such as fruit, vegetable, and grain, may increase antioxidant activity and can be consumed as a healthy food against diseases caused by free radicals and oxidative stress [18][19]. Milk proteins and peptides, such as lactoferrin have shown activities as anti-cell proliferation, antioxidant, and anti-inflammatory [6][7]. The presence of...
glutathione and immunoglobulins enhancing antioxidant capacities of the cell [7][19]. [20] was confirmed that casein in yogurt has protected the liver in dioxin-intoxicated rats from damaging.

Black rice bran has the highest phenolic compound, and other bioactive compounds such as γ-oryzanol, α-tocopherol, and γ-tocopherol compared to RD6 and red rice [11]. γ-oryzanol is a potential antioxidant, chemopreventive, anti-inflammatory, and lipid-lowering [12]. LAB fermentation of rice bran has been proved increasing the antioxidant activity higher than fermented skim milk. [21] confirmed that there was a close correlation between antioxidant activity and phenol content. During the fermentation process, LAB degrades fiber into a simpler compound, breaking the covalent bond between phenolic compounds and insoluble fat, increasing the antioxidant bioavailability of rice bran [18]. Natural phenolic compound known has an antioxidant effect by reducing oxygen concentration, scavenging initial free radicals, and decomposing primary products of oxidation to nonradical species.

4. Conclusion
Fortification of yogurt with goat milk yogurt made differences in its nutritional value compared to plain yogurt. Black rice bran-fortified yogurt had higher protein, ash, and carbohydrate content and lower fat and water content. Black rice bran-fortified goat milk yogurt had higher antioxidant activity.

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Acknowledgments
Gratitude is given to Universitas Brawijaya, Malang, Indonesia for the research grant and to Laboratory of Veterinary Public Health, Faculty of Veterinary Medicine, Universitas Brawijaya, Malang, Indonesia for the facilities during the work of this study.