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Antioxidant Effect of White and Black Rice Addition on Robusta Coffee Powder and Brews Characteristics

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Abstract

The processing methods of coffee bean are various in different regions in Indonesia. One of the methods is by adding the material of coffee bean with other ingredients such as rice. This research was aimed to investigate the effect of adding white and black rice into the yield and quality of robusta coffee within its powder and brews. The experiment used the completely randomized design, with three treatments namely: pure coffee; coffee+white rice; and coffee+black rice. Observation parameters consisted of: rendement;color; organoleptical properties; and antioxidant activity. The results showed that the addition of black or white rice (30%) did not affected the yield, pannelist's preference for color, and the bitter level of coffee brews. However, the addition of white or black rice had a significant effect on the degree of lightness and the antioxidant activity of the coffee powder, also the panelist's preference for the aroma and taste for coffee brews. The black rice addition showed to be more preferred which scored 3.18 for aroma and 3.55 for taste than white rice addition in coffee brews. Moreover, the color of the coffee powder of coffee + black rice became brighter (L = 35), and the antioxidant activity was increased to reach 44.74% as the highest among other treatments. The black rice addition could be used to improve the antioxidant activity of the commercial robusta coffee powder and brews with fairly consumer acceptance.

1. INTRODUCTION

Coffee is one of the plantation commodities that have a high economic value among other plantation crops and plays an important role as a source of foreign trade exchange. Coffee is also a source of income for approximately one and a half million coffee farmers in Indonesia (Rahardjo, 2012). Two types of coffee that commonly consumed are Robusta and Arabica coffee, where Robusta coffee holds 73.5% of total Indonesian coffee production (DGEC, 2015). In present and the following decade, Chandra et al. (2013) asserted that the coffee demand and export volume will increase.

Meanwhile, the quality of coffee powder is influenced by many things such as, varieties, and postharvest handling of the coffee beans (Hutabarat, 2006). According to Clarke and Macrae (1987) the Robusta and Arabica coffee have different characteristics. Robusta has a higher total chlorogenic acid and caffeine content, while Arabica contains relatively higher amino acids and fats.

The increase of powdered coffee production in Indonesia is still hampered by the low quality of coffee beans that produced. This is due to improper postharvest handling in many stages, such as fermentation, washing, sorting, drying, and roasting. Therefore, to obtain a good quality of coffee beans, it is necessary to conduct a proper postharvest handling and processing at each stage to obtain the demanded quality. According to Choiron (2010), the application of appropriate standard operating procedure is very important, even it can reduces the levels of ochratoxin; increases and uniforms the quality of coffee that produced by farmers. Ochratoxin is a toxic compound that is harmful into human body. This compound is produced by *Aspergilus* species that may occur due to improper handling.

The quality of coffee, besides being influenced by postharvest handling, it is also very dependent on the whole process, where one of which is in the roasting stage. Some people in Indonesia, specifically in East Java, they used to make a coffee powder which mixed with other ingredients such as corn, rice, or coconut. There are also other ways in other areas that mix coffee beans with sticky rice, areca and corn (Syah et al., 2013). These ingredients mixing, besides aimed to increase the volume of coffee powder, it is also produce coffee powder with a distinctive taste and aroma, such as savory and more concentrated bitter. In addition, the antioxidant activity contained in added materials such as rice (Dwiyanti, et al., 2013; Walter et al., 2013) are prospective to improve the nutrient quality of coffee brews.

Black rice can be a local variety that contains the best pigment compared to white rice or other colored rice (Sa'adah, et al., 2013). The pigments or dyes belonging to the flavonoid group which called as anthocyanins. The anthocyanin is an antioxidant that has a positive effect on human health. Black rice is a type of black (dark) colored rice with higher antioxidant content than white rice. Black rice has potassium content per 100 grams of 105 mg, protein to be found as much as 7.88% and carbohydrates as much as 74.81%. Colored rice has an antioxidant which has a molecular structure that provides free electrons into free radical molecules without interrupting its function and can break free the chain reaction of free radicals.

To know the potential of white rice and black rice in coffee processing and to investigate the quality of coffee produced, it is necessary to conduct a research of coffee processing with addition of white rice and black rice. Therefore, it is expected that the results of this study could support the repertoire of knowledge in general for the community of coffee bean processing.

2. MATERIALS AND METHODS

The research was conducted in January-February 2017, at the post harvest and mechanization technology laboratory of the

Assessment Institute for Agriculture Technology (AIAT) of East Java. The materials and equipments that used were Robusta coffee beans, white rice of Ciherang variety, black rice obtained from local market, clay fryer, wood stirrer, liquid petroleum gas stove, disk mill, and 80 mesh of sieve.

The experimental design used the completely randomized design with rice addition factors and three levels of treatments namely: 1) pure coffee; 2) coffee bean + white rice with ratio of 70:30, and 3) coffee bean + black rice with ratio of 70:30, using six repetitions.

The coffee bean was fried in clay made frying pan based on the ordinary method that used in Indonesia. Initially, the clay frying pan was heated for 30 minutes then fulfilled with assorted coffee bean followed by toasting for 30 minutes. Later on, the clean and dry of black or white rice were mixed together in the clay frying pan and then roasted for 1.5 hours in 180°C. Later on, the mixed material was cooled, followed by grinding and sifting for the desirable size to make the coffee powder. This method is described in Figure 1.

Hereafter, the coffee powder was tested for its physical and chemical properties namely: 1) rendement; 2) color in red-green (*a*); yellow-blue (*b*) and lightness (*L*); 3) organoleptical properties of coffee brews; and 4) antioxidant activity. The Organoleptical test was conducted using the hedonic test scoring of 1 to 5; they were: 5 = very like, 4 = like, 3 = neutral, 2 = dislike and 1 = very dislike; used as much as 25 semi-trained panelists with parameters of color, , bitterness, taste and overall preference.

Rendement was measured using the ratio of dry coffee bean and the coffee powder weight. Color parameters were measured using portable colorimeter of Puxi type HP-2136. Meanwhile, the antioxidant activity measurement was conducted by adopting method from Yue and Xu, (2008) that used the 2-diphenyl-1-picrylhydrazyl or known as the DPPH method. The extracted sample was mixed with the DPPH reagent and then incubated in the dark room for 30 minutes. The absorbance was measured at 517 nm by spectrophotometer and the antioxidant activity was calculated using the following formula:

$$Antioxidant\ activity\ (\%) = Ad - \left(\frac{As}{Ad} X100\%\right)$$

where Ad was the DPPH absorbance, while As was the sample absorbance.

Data were analyzed in statistics which performed using the Analysis of Variance (Anova) followed by Duncan multiple range test at 5% level.

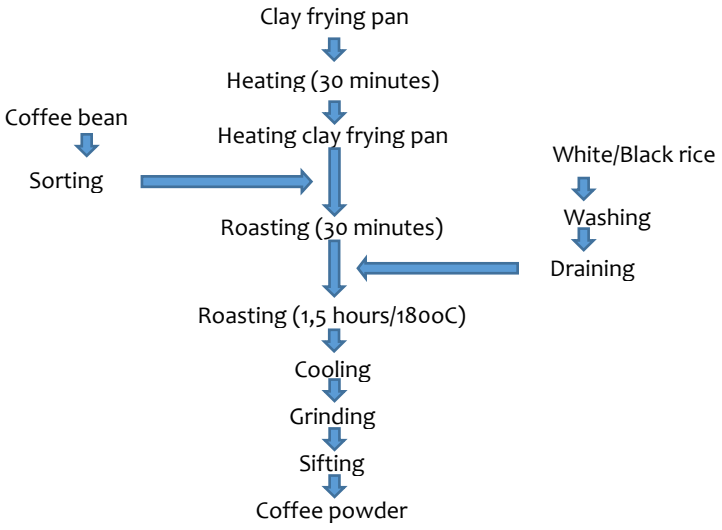

Figure 1. Flow chart of coffee powder processing

3. RESULTS

The physical and chemical properties of coffee drinks was represented by its bean and coffee brews characteristics in rendement; visual color and degree of lightness; organoleptical properties; and antioxidant activity and sequentially described in the following.

Rendement.

Stages in the coffee powder processing were greatly enables weight shrinkage resulted in yield or rendement. The rendement referred to the amount of coffee powder resulted after it was grinded. The previous stage may caused the moisture to evaporate while the utilization of disk mill in the process produced a specific quality and quantity of rendement. The highest rendement was obtained from coffee + black rice of 85%, while coffee + white rice produce the smallest (78.67%) less than pure coffee of 82%. In accordance, the weight loss was at the lowest obtained from coffee+black rice, while the highest was obtained from coffee+white rice (Table 1). The analysis of variance for the resulted coffee powder showed that there were no significant different among all rendement that produced ($p>0.05$), likewise the weight loss in accordance. Practically, the process did not significantly affect the rendement and weight losses of the resulted coffee powder for all treatment.

Table 1. Rendement and weight loss of coffee powder.

No.	Treatment	Rendement (%)	Weight loss (%)
1.	Pure Coffee	82.00[a]	18[a]
2.	Coffee+White rice	78.67[a]	21.33[a]
3.	Coffee+Black rice	85.00[a]	15[a]

Visual Color and Degree of Lightness.

Lightness is technically defined as the perceived brightness of an object compared to that of a perfect white object. Visually, coffee beans and coffee powder were look different in color between all treatments. Pure coffee has a darker color, or having the lowest degree of lightness, whereas coffee + white and coffee + black rice were slightly reddish in color (Figure 2).

Figure 2. Comparative appearance of the coffee bean and coffee powder for all treatments.

The degree of lightness indicates the lightness value of a product, the greater its value means brighter while otherwise is more pale. The degree of lightness is presented in *L* (lightness level), a (green-red level), and b (yellow-blue) level). Based on the results of statistics analysis (table 2), it was showed that the addition of white rice and black rice had an effect on the degree of lightness of the coffee powder (p <0.05). Pure coffee powder had the lowest degree of lightness or the darkest (L = 32.10). The addition of black rice and white rice caused the coffee powder to be brighter on coffee+white rice and coffee+black rice (L = 32.92-35.00).

The *a* (green-red) and *b* (yellow-blue) values of coffee+black rice and coffee+white rice were not significantly different. This showed that the coffee powder made by adding 30% of white rice was not different with the coffee powder made by adding 30% of black rice. The a+ values ranged from 10.10 to 11.42, were not significantly different between all treatments. Similarly, the b + values ranged from 9.02 to 11.32, were not significantly different between treatments (Table 2).

Table 2. Color parameters degrees of coffee powder (*L, a, b*).

No.	Mixture	*L*	*a*	*b*
1.	Pure Coffee	32.10^{b}	$+10.10^{a}$	$+9.02^{a}$
2.	Coffee+White rice	32.92^{ab}	$+11.42^{a}$	$+11.07^{a}$
3.	Coffee+Black rice	35.00^{a}	$+11.07^{a}$	$+11.32^{a}$

Remarks: - Mean values within a column followed by the same letters are not significantly different at 5% level.
-*L*: indicates lightness, range between 0-100 (0 = black, 100 = white).
-*a*: shows green and red colored (a + = red, a- = green)
-b: shows yellow and blue colored (b + = yellow, b- = blue)

Organoleptical Characteristics of Coffee Brews

The result showed that the level of preference for the organoleptical properties of coffee brews which were consisting of aroma, taste and overall appearance, was different significantly for all treatments (p<0.05), but not significantly different in color and bitter level of coffee (p>0.05). The color of the coffee brews ranged from 3.64 to 4.18 (neutral-like). The bitter level of coffee brews ranged from 2.90 to 3.18 (neutral). The aroma of coffee brews ranged from 2.90 to 4.09 was significantly different between treatments (p<0.05), and the highest score was 4.09 (preferably) for pure coffee, while coffee+black rice scored 3.18 (neutral). The taste of coffee brews ranged from 3.00 to 3.91, significantly different between treatments (p<0.05), with the highest score of 3.91 (preferably) obtained from pure coffee treatment, and 3.55 (preferably) for coffee+black rice treatment (Table 3 and Figure 3). In general, pure coffee was still preferable to panelists, but when compared between coffee+white rice and coffee+black rice, the coffee+black rice mixture was preferred.

Moreover, the pannelist preferences were grouped in positive preference that referred to have a positive correlation with the increase number of parameter value, while negative referred to negative correlation with the parameters value which in here described by the level of bitterness. Neverthelles, bitter taste can be one of common coffee characteristics that may affect the overall consumer preference. The overall preference of positive organoleptical parameters showed that the pure coffee was still posed as the most preferred followed by the black rice addition and the white rice addition as the lowest (Figure 3).

Table 3. Panelist preference on organoleptical properties of coffee brews.

No.	Treatment	Preference				
		Color	Aroma	Bitterness	Taste	Overall
1.	Pure Coffee	3.91[a]	4.09a	3.09a	3.91a	4.00a
2.	Coffee+White rice	3.64a	3.00b	2.90a	3.00b	3.27b
3.	Coffee+Black rice	4.18a	3.18b	3.18a	3.55ab	3.72ab

Remarks: Mean values within a column followed by the same letters are not significantly different at 5% level.

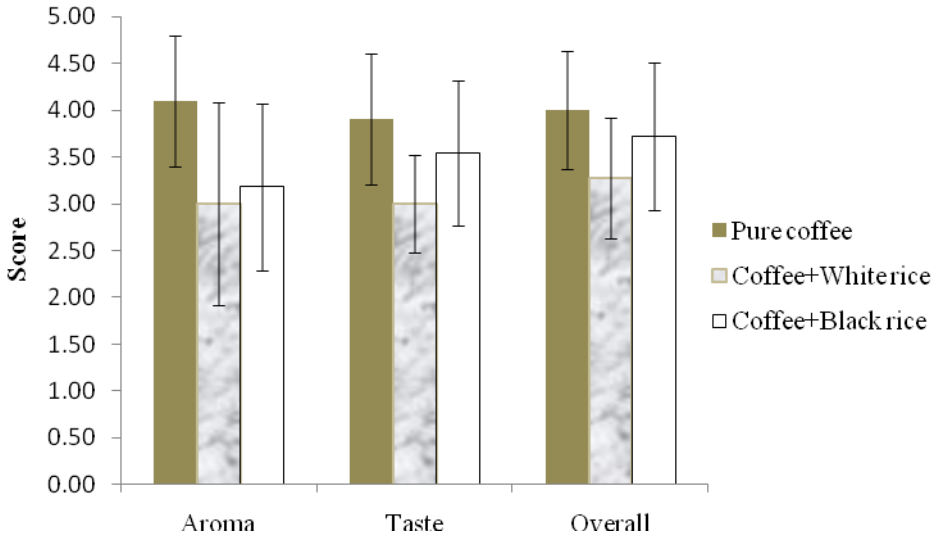

Figure 3. Organoleptical parameters (aroma, taste and overall) preferences of coffee brews from pure coffee, coffee + white rice, and coffee + black rice that showed different significantly at 5%level.

Antioxidant Activity

Referred to the coffee nutrient quality improvement, the antioxidant activity can be as an important parameter to be concerned. How far it is can be achieved when antioxidant conveyed material added describes the nutrient quality improvement. The results showed that the antioxidant activity of coffee+black rice and coffee+white coffee powder were significantly different from pure coffee (p<0.05). While the coffee+ black rice and coffee+white rice's antioxidant activity was higher than pure coffee ranged from 44.667 to 44.745%), while the antioxidant activity of the pure coffee was 11.335% far less than the other mixture treatments (Table 4).

Table 4. Antioxidant aactivity of coffee powder.

No.	Treatment	Antioxidant Activity (%)
1.	Pure Coffee	11.335b
2.	Coffee+White rice	44.667a
3.	Coffee+Black rice	44.745a

Remarks: Mean values within a column followed by the same letters are not significantly different at 5% level

4. Discussion

Based on the statistical analysis, the substitution of white rice or black rice did not affect the rendement and weight loss of coffee powder (p>0.05). It may happened because the moisture in both coffee beans and rice were evaporated caused by roasting and

grinding process, but it was not different significantly relative to all average. According to Varnam and Sutherland (1994), roasted coffee beans are divided into three kinds of light roast for temperature of 193-199°C; medium roast of 204°C; and dark roast of 213-221°C. In light roast, 3-5% weight is loss, 5-8% for medium roast and 8-14% for dark roast. In addition, a good result was obtained by 200°C of roasting in 12 minutes with controlled temperature (Nugroho and Joko , 2009). Moreover, the loss in weight reached up to 21.33%, where it may indicated that beside Continued to the bean and the coffee powder color characteristic, the addition of black rice and white rice caused the coffee powder to be brighter. The color of the beans and the coffee powder were influenced by the degree of roasting; the longer time spent in the roasting stage, the coffee beans and powder will get more black or dark commonly known as the dark roasting degree. Nevertheless, the color of coffee powder is also influenced by the raw material, if the coffee bean is mixed with other ingredients such as rice, then the resulting color of coffee powder will be different.

Moreover, the value of green-red (*a*) and yellow-blue (*b*) color were showed insignificant different. It had been found previously that before it roasted, coffee beans lightness (*L*) value ranges 60-65. In light roasting, the color of the coffee bean surface became browner so that the value of *L* was decreased to 44-45. In medium roasting, the *L* value of coffee beans was dropped back to 38-40 and in dark roasting the coffee beans became darker to reach 34-35. At this stage, where it was also occurred in the observation, the hydrocarbon compound was pyrolyzed to become carbon element and sugar compound through caramelization process, so that the colored beans were getting closer to black and shiny (Mulato, 2002).

Furthermore, the coffee brews were still more preferred in overall rather than the rice adding mixture. However, the coffee+black rice mixture preference was not different significantly with pure coffee which showed its prospect to maintain the consumer preference. According to Wahyudi and Ismayadi (1995) each coffee is unique in its characteristic and taste. Compounds that play the role for its aroma are sugar, volatile compounds, trigonelline, amino acids and peptides. In addition, sugar also plays a role in staining during roasting. While the taste and its brews is much influenced by carboxylic acids and phenolic acids (Nopitasari, 2010). Robusta coffee has a more chocolate-like and bitter taste, a distinctive and sweet aroma, the bean color is varies depending on the way it is treated, while the texture is rougher than Arabica coffee (Anggara and Marini, 2011). Bitter taste of extracted coffee is a joint of mineral with the breaking of crude fiber, chlorogenic acid, caffeine, tannins and other organic and inorganic compounds (Nopitasari, 2010; Varnam and Sutherland, 1994). The bitter taste in coffee is influenced by the degree of roasting; the type of coffee and the processing method. According to Rouseff (1990), Robusta coffee has a higher content of chlorogenic acid than Arabica coffee. Typical aromas are formed in the roasting stage, where the sugar compounds will be caramelized, whereas the compounds that cause sponge or acid taste such as tannins and acetic acid will disappear and some will react with amino acids to form melacide compounds that forms a brown color (Mulato, 2002).

A prospective finding also achieved in the mixture treatments where showed by the increment of the antioxidant activity. It was showed by statistical analysis that the white and black rice addition increased the antioxidant activity of the resulted coffee powder and coffee brews. In term of nutrient quality, the rice addition (white or black) can increase the antioxidant activity.

Black rice contains anthocyanins that act as antioxidants. The common anthocyanin in black rice is cyanidin-3-glucoside (C3G) where it is an important source of anthocyanin in Asia. Black rice also contains an active

phytochemicals such as tocopherols, tocotrienols, oryzanols, vitamin B complex and phenolic compounds (Sa'adah et al., 2013). Moreover, a higher roasting temperature on coffee bean is tending to keep its antioxidant activity (Cammerer and Lothar, 2006). Hence, the research result affirmed that different coffee bean and rice variety with different processing method resulted in different level of antioxidant activity (Gebeyehu and Solomon, 2015; Dwiyanti, et al., 2013; Walter et al., 2013).

As a beverage product, coffee brews could be served in many unique ways to achieve a better consumer preference. The rice addition in this research showed the potential of nutrient improvement of coffee brews with the increment of antioxidant activity especially for commercial purpose

5. Conclusion

The addition of 30% of white or black rice increased the antioxidant activity (44.67-44.74%) and brightened the color of coffee powder (*L* = 32.92-35.00). Whereas, in term of organoleptical quality (aroma, and overall) of coffee brews, 30% of black rice addition was preferred over 30% of white rice addition, but it was not significantly more favorable than the pure coffee mixture.

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