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Effects of Varieties and Cooking Methods on Physical and Chemical Characteristics of Cooked Rice

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Abstract: To analyze the effect of different lowland rice varieties and different cooking methods on physical and chemical characteristics of cooked rice. A factorial randomized block design with two factors was used and each combination of the factors was repeated three times. The first factor was rice variety (Ciherang and Ciliwung) and the second factor was the cooking method (stovetop, boiling and steaming, and rice cooker). Results showed that Ciherang and Ciliwung varieties were classified into slender grain rice type with yellow-red color. The amylose content of Ciherang was classified as moderate, while the amylose content of Ciliwung classified as low. The most abundant amino acid contained in Ciherang and Ciliwung varieties was glutamic acid. Statistical analysis showed that cooking method had significant effects on texture, lightness, chroma, hue and moisture content of cooked rice. Rice cooked with *liwet* method had the lowest texture value, lowest lightness value, highest chroma value, and highest moisture content.
Key words: physical and chemical characteristic; cooking method; rice; variety; amino acid

Rice was one of the most important commodity results in farming systems in the lowland swamp of Indonesia. Lowland swamp land cultivated for rice farming with cropping pattern once a year was 91%, while for rice farming with cropping pattern twice a year was only about 9% (Sudana, 2005). Various rice varieties namely Ciherang, Ciliwung, Mekongga, IR10, IR42, IR64, Ciherang Dempo, Ciliwung Jumbo and Rojo Lele were grown in lowland swamp area (Syafutri, 2015). Ciherang and Ciliwung were varieties widely grown by farmers in lowland swamp land. The difference of rice varieties would affect the characteristics of cooked rice produced. According to Yadav et al (2007), different rice varieties showed significant effects on the physicochemical properties, morphology and cooking properties, but Putri (2012) stated that the starch content of rice was still the same, ie more than 80%. Cooking method also affected the characteristics of cooked rice. According to Han et al (2008), different cooking method would affect the hydrolysis of starch rice. Cooking the raw rice into the cooked rice could be done in various ways. Indonesian people used two ways to cook rice namely conventional and modern ways. The conventional way consisted of *liwet* method using stovetop, and combination of boiling and steaming method. The modern way was cooking rice using electric rice cooker. Each cooking method used different heat and cooking time. The objective of this study was to analyze the effect of different lowland rice varieties and different cooking methods on physical and chemical characteristics of cooked rice.

MATERIALS AND METHODS

Rice materials

Rice varieties Ciherang and Ciliwung were derived from lowland swamp land at East Ogan Komering Ulu, South Sumatera, Indonesia.

Cooking methods

Factorial randomized block design was used with two treatment factors and three repetitions. The treatment factors were rice variety (A) and the cooking method (B). The first factor consisted of two levels, Ciherang (A_1) and Ciliwung (A_2), whereas the second factor consisted of three levels, *liwet* method using stovetop (B_1), combination of boiling and steaming (B_2) and rice cooker (B_3). The data obtained were evaluated using analysis of variance (ANOVA) and honestly significant difference test at the 5% level. Physical and

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chemical characteristics of milled rice and cooked rice were studied.

Liwet method using stovetop

The procedures of *liwet* method (Deliani, 2004) which have been modified were: first, milled rice with whole grains (100 g) was cleared from foreign objects and dirt. Second, rice was washed with clean water (two times) and drained for 2 min, then put in a regular pot or pan pot. Next step, water (150 mL) was added to the pot containing. Fourth, the rice was cooked in a covered pot until boiling. Then, stirring was alone done 10 times after water boiling (100 °C). Sixth, if the water was up, stirred again (stirring the latter performed 5 times and the pot sealed while the fire diminished). Last, the cooking times of *liwet* method were 10 min.

Combination of boiling and steaming method

The procedures of boiling and steaming combination method (Deliani, 2004) which have been modified were: first, milled rice with whole grains (100 g) was cleared from foreign objects and dirt. Second, rice was washed with clean water (two times) and drained for 2 min, then put in a regular pot or pan pot. Third, water (150 mL) was added to the pot containing. Next, the rice was cooked in a covered pot to a boil for 5 min, then reduced the heat (during heating stirring 15 times until becoming rice (water absorbed by rice). Fifth, stirring was done 10 times after water boiling (100 °C) to become rice (water absorbed by rice). Then, rice was stirred and moved to the steamer containing boiled water, then waited for 5 min.

Rice cooker method

The procedures of modern cooking method (rice cooker) (Sutarjana, 2009) which have been modified were: first, milled rice with whole grains (100 g) was cleared from foreign objects and dirt. Second, rice was washed with clean water (two times) and drained for 2 min and put in an aluminum pan on the rice cooker. Then, 150 mL water was added. Fourth, thermostat was clicked and light 'cooking' light up on the rice cooker to cook the raw rice into the cooked rice. Finally, the thermostat button will automatically moved from the position of the light 'cooking' to the position of the lights 'warmer' that shows rice cooked.

Measurement of physical and chemical characteristics

The physical characteristics of milled rice included size (dimentions of rice) and color, whereas the chemical characteristics of milled rice included moisture content, amylose content, protein content and total amino acids. The physical characteristics of cooked rice were color and texture, while the chemical characteristic was moisture content.

Rice dimensions including length and width were measured using calipers. Whole rice intact (10 seeds) was taken from each variety. Texture of rice was measured with 'Brookfield' texture analyzer (Faridah et al, 2006). Brook (cylindrical type) mounted just above the sample. The needle was attached to the tip of the sample. Speed of texture analyzer was set. Brooke (blade type) pressing right in the middle of the sample. Then, on display listed number of peak load and final load (gram force). Analysis of color was measured using a Konica Minolta Chromameter. Lightness, chroma and hue were measured according to Anonymous (1997). Chemical characteristics were determined using method of AOAC (2006).

RESULTS

Dimentions of rice

Ciherang had length of 7.01 mm and width of 2.04 mm, whereas Ciliwung had length of 6.75 mm and width of 2.10 mm. The ratio of length and width for Ciherang was 3.44, while that for Ciliwung was 3.21.

Texture

Texture indicated the hardness of rice. Physically, hardness of cooked rice defined as rice ability to accept certain load in certain time. Analysis of texture could determine hardness and tenderness of rice. Based on this study, average textures of cooked rice were 25.70 to 33.00 gf (Fig. 1). Analysis of variance showed that cooking method had significant effect on texture of cooked rice, while rice variety and interaction between cooking method and rice variety had no significant effect on texture of cooked rice. The cooked rice with high texture value was harder than that of low texture value.

Color

Color analysis was conducted on milled rice and cooked rice with attributes of lightness, chroma and hue. The maximum value of lightness was 100% that showed very white.

The lightness values of milled rice were 65.97% (Ciherang) and 67.93% (Ciliwung). The lightness values of cooked rice with different varieties and cooking methods ranged from 73.07% to 76.20% (Fig. 1). The highest lightness value (76.20%) was found in rice with A_2B_3 treatment (Ciliwung variety and cooking method using the rice cooker), while the lowest lightness value (73.07%) was found in rice with A_1B_1 treatment (Ciherang variety and *liwet* method). The high lightness value of rice indicated that the color of rice was brighter. The analysis of variance showed that cooking method had significant effect on lightness of cooked rice, while rice variety and interaction between cooking method and rice variety had no significant effect on lightness of cooked rice.

The chroma values of milled rice were 12.03% (Ciherang) and 12.00% (Ciliwung). The chroma values of cooked rice with different varieties and cooking methods ranged from 5.63% to 7.10% (Fig. 1). The highest chroma value (7.10%) was found in rice with A_1B_1 treatment (Ciherang variety and *liwet* method), while the lowest chroma value (5.63%) was found in rice with A_2B_3 treatment (Ciliwung variety and cooking method using the rice cooker). The analysis of variance showed that cooking method had significant effect on chroma of cooked rice, while rice variety and interaction between cooking

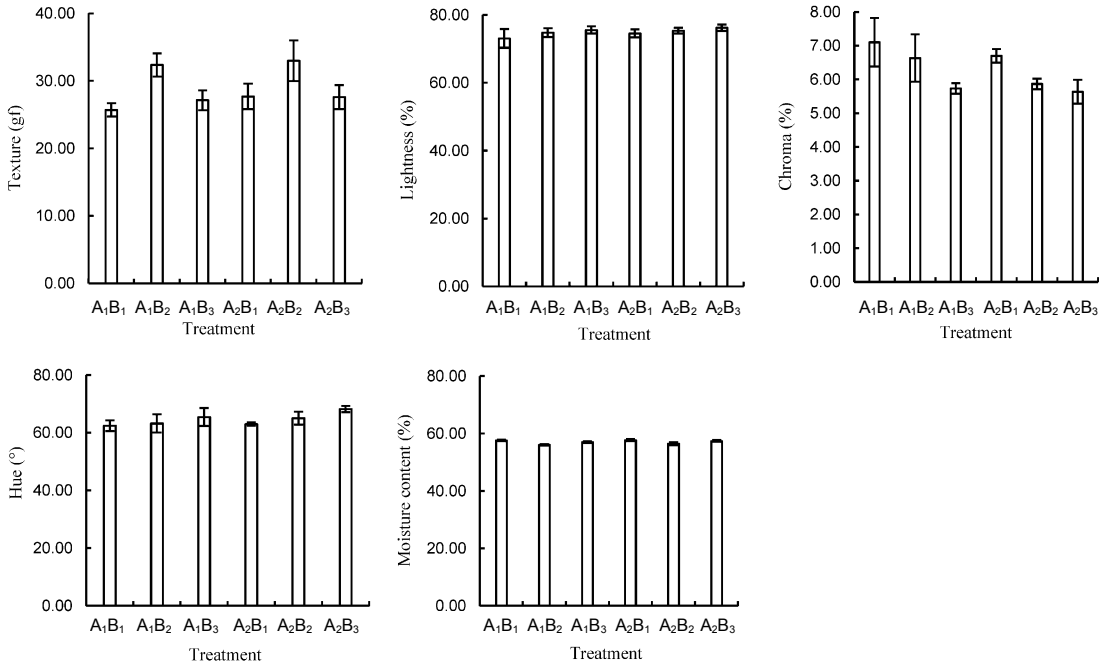

Fig. 1. Physical and chemical characteristics of cooked rice.
A_1, Ciherang; A_2, Ciliwung; B_1, *Liwet*; B_2, Combination of boiling and steaming method; B_3, Rice cooker.

method and rice variety had no significant effect on chroma.

The hue values of milled rice were 69.37° (Ciherang) and 65.70° (Ciliwung). The hue values of cooked rice with different varieties and cooking methods ranged from 62.43° to 68.20° (Fig. 1). The highest hue value (68.20°) was found in rice with A_2B_3 treatment (Ciliwung variety and cooking method using the rice cooker), while the lowest hue value (62.43°) was found in rice with A_1B_1 treatment (Ciherang variety and *liwet* method). The analysis of variance showed that cooking method had significant effect on hue of cooked rice, while rice variety and interaction between cooking method and rice variety had no significant effect on hue of cooked rice. According to hue value, Ciherang and Ciliwung varieties with different cooking method had yellow-red (YR) color.

Moisture content

The moisture content was measured in milled rice and cooked rice. The average moisture content of Ciherang was 12.27%, while that of Ciliwung was 12.22%. The moisture contents of cooked rice with different varieties and cooking methods ranged from 56.01% to 57.68% (Fig. 1). The highest moisture content value (57.68%) was found in rice with A_2B_1 treatment (Ciliwung variety and *liwet* method), while the lowest moisture content (56.01%) was found in rice with A_1B_2 treatment (Ciherang variety and combination of boiling and steaming method). The analysis of variance showed that cooking method had significant effect on moisture content of cooked rice, while rice variety and interaction between cooking method and rice variety had no significant effect on moisture content of cooked rice.

Amylose content

Determination of amylose content was started with the making of standard curve, where the resulting regression equation was $y = 0.0217x - 0.0161$. The average value of amylose content with treatment A_1 (Ciherang) was 22.64%, while the average value of amylose content with treatment A_2 (Ciliwung) was 18.85%.

Protein content and total amino acid

Protein content and total amino acids of Ciherang were 10.73% and 7.75%, respectively, while protein content and total amino acid content of Ciliwung were 8.98% and 6.98%, respectively (Table 1). Total amino acid content was observed consisting of 10 essential amino acids and 5 non-essential amino acids. The most abundant amino acids contained in Ciherang and Ciliwung, namely glutamic acid (non-essential amino acids), were 1.68% and 1.49%, respectively.

DISCUSSION

According to Setyono and Wibowo (2008), a length of 6.6 to 7.5 mm was classified as long grain rice. Based on the ratio between length and width, Ciherang and Ciliwung were included into long grain rice type and rice shape slender (ratio of length and width ≥ 3.0) (Slaton et al, 2000; Setyono and Wibowo, 2008). The slender rice was more preferable by consumers.

Rice cooked with *liwet* method had low texture value. It caused the texture of cooked rice softer than the other methods.

Table 1. Protein and total amino acid contents of Ciherang and Ciliwung varieties. %

Component	Ciherang	Ciliwung
Protein	10.73	8.98
Total amino acid	7.75	6.98
Aspartic acid	0.79	0.69
Glutamic acid	1.68	1.49
Serine	0.47	0.43
Histidine	0.21	0.19
Glycine	0.36	0.34
Threonine	0.29	0.27
Arginine	0.69	0.59
Alanine	0.47	0.43
Tyrosine	0.30	0.26
Methionine	0.13	0.14
Valine	0.49	0.44
Phenylalanine	0.49	0.44
I-leucine	0.37	0.34
Leucine	0.72	0.64
Lysine	0.29	0.30

During cooking process with *liwet* method, rice absorbed water and starch granules would swell. Cooking process with *liwet* method performed heating temperature setting. The heating temperature setting included the big fire which used to accelerate the process of heating water reaching the boiling point temperature of water (100 ^{o}C), moderate heat to ripen the rice, and a small fire to prevent the formation of a thick crust. Heating temperature setting was done from the boiling water and rice to the rice maturation. Setting the temperature during *liwet* methods caused heat exposure on rice longer than the other two methods. Exposure to prolonged heat caused the texture of rice softer. Cooking rice with combination of boiling and steaming method had the highest value of texture, and hence the rice produced had a harder texture than the other two methods. Cooking rice with combination of boiling and steaming method had the highest average value of texture because at the time after water boiled at 100 ^{o}C, the water was absorbed into the rice and then the fire was turned off. Furthermore, the rice cooled and occured re-arrangement of amylose that leads to retrogradation process before entering the stage steaming, and consequently the texture of rice produced was louder. According to Winarno (2004), retrogradation was a re-crystallization process of starch which had undergone gelatinization. One of the factors that affect the texture of rice was gelatinization process, which was necessary for cooked rice (Marshall, 1994). Gelatinization process occured during the rice heating in water until it became cooked rice. Gelatinization temperature affected the ripening time. Rice with a high gelatinization temperature needed a longer cooking time than rice with a low gelatinization temperature.

Lightness indicated the brightness or darkness of a color (Winarno, 2004). High lightness value of rice indicated that the color of rice was brighter. Lightness value of cooked rice was affected by cooking temperature and time. The rice cooked using *liwet* method had the lowest lightness value. Cooking process with *liwet* method performed heating temperature setting manually, which caused heat exposure on rice longer than other methods. This heating process caused a browning reaction between carbohydrates and protein, and produced darker rice (yellow-red), indicated by low value of lightness. The rice cooked using rice cooker had the lowest value of chroma. The chroma values were affected by temperature and cooking time for each cooking method. The cooking process using a rice cooker required shorter time than the other methods, and hence the heating process for cooker was faster. Accelerated warming process would minimize the risk of browning reaction (Maillard) on rice, so that rice produced had a weak color indicated by lower chroma values. Browning reaction (Maillard) caused higher chroma values on rice. According to hue value, Ciherang and Ciliwung had yellow-red color. Formation of colors on rice was affected by heating process. During the heating process, reaction between the protein and reducing sugar occured, and it caused the formation of glycocylamine. Glycocylamine suffered polymerase to form melanoidin which caused color changes of rice to yellow red (Maillard reaction) (Wahyudi, 2005).

Water was one of the important elements in food stuffs. According to Sudarmadji et al (2007), the moisture content was the amount of water contained in food, including free water and water bound physically and chemically. According to Anonymous (1999), the maximum moisture content of milled rice was 14%. Cooking rice with *liwet* method had the highest moisture content, because of longer rice exposure to heat, and therefore, the texture was softer than that of the other methods. In addition, water trapped in the pan could be absorbed back into the rice during the resting time after the fire turned off, and thus cooking with liwet method affected the moisture content of the rice.

Amylose content was one of the important criteria in the classification system of rice. The amylose content of Ciherang was classified as moderate, while the amylose content of Ciliwung classified as low. According to Allidawati and Bambang (1989), based on the amylose level, rice was grouped into very low amylose (< 10%), low (10% to 20%), moderate (20% to 24%) and high (> 25%). Higher amylose content in rice increased the occurrence of rearrangement of amylose after experiencing gelatinization leading to retrogradation process. Rice with high amylose would produce no sticky rice, could expand and became hard when it was cold. Moderate amylose rice had fluffier texture generally. Low amylose rice produced sticky rice, shiny, not expand, and still coagulate after cold (Damardjati, 1995; Indrasari et al, 2009).

Protein content of Ciherang and Ciliwung were 10.73% and 8.98%, while total amino acids of Ciherang and Ciliwung were 6.98% and 7.75%, respectively. The most abundant amino acid in Ciherang and Ciliwung was glutamic acid (non-essential amino acids). According to the Nutrition Directorate of the Ministry of Health (1996), the protein content of rice was 7.6%. According to Haryadi et al (2008) and Larasati (2012), protein contents of rice ranged from 7.3% to 10.2% and a maximum of 14.0%. According to Haryadi (2008), the rice containing higher

protein needed more water and a longer cooking time. This related to the structure of rice grains. The starch granules enclosed in a protein, and hence the absorption of water was blocked by protein, which resulted in a longer time of cooking.

CONCLUSIONS

Ciherang had a length and width ratio of 3.44, lightness of 65.97%, chroma of 12.03%, hue of 69.37°, moisture content of 12.27%, amylose content of 22.64%, protein content of 10.73%, and total amino acid of 7.75%. Ciliwung had a length and width ratio of 3.21, lightness of 67.93%, chroma of 12.00%, hue of 65.70°, moisture content of 12.22%, amylose content of 18.85%, protein content of 8.98%, and total amino acid of 6.98%. Cooking method had significant effects on texture (hardness), color (lightness, chroma and hue) and moisture content of the cooked rice.

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REFERENCES

Allidawati, Bambang K. 1989. Quality Test Method of Rice in Rice Breeding Program. Bogor, Indonesia: Center for Food Crops Research and Development: 363–375.

Anonymous. 1997. Munsell Colour Chart of Tissue. Maryland: Baltimore.

Anonymous. 1999. Quality Standards and Test Methods for Milled Rice (SNI 01-6128–1999). Jakarta, Indonesia: National Standardization Agency.

AOAC. 2006. Official Methods of Analysis. Washington DC, USA: Association of Official Analytycal Chemistry.

Damardjati D S, Purwani E Y. 1991. Quality of Rice. Sukamandi, Indonesia: Crops Research Institute for Food, **4**(4): 85–94.

Deliani L. 2004. Studying the Effect of Several Rice Varieties Storage with Different Levels of Sticky on Parboiling Quality. Bogor, Indonesia: Faculty of Agricultural Technology, Bogor Agricultural University.

Faridah D N, Kusumaningrum H D, Wulandari N, Indrasti D. 2006. Analysis Laboratory. Bogor, Indonesia: Department of Science and Technology, Bogor Agricultural University.

Han S H, Lee S W, Rhee C. 2008. Effects of cooking methods on starch hydrolysis kinetics and digestion-resistant fractions of rice and soybean. *Eur J Food Res Technol*, **227**(5): 1315–1321.

Haryadi. 2008. Rice Processing Technology. Yogyakarta, Indonesia: Gadjah Mada University Press.

Indrasari S D, Purwani E Y, Widowati S, Damardjati D S. 2009. The enhancement of value added of rice through physical quality, taste and nutrition. Sukamandi, Indonesia: Rice Research Institute.

Larasati S P. 2012. The properties of physicochemical and organoleptic characteristics of several rice varieties. Bogor, Indonesia: Department of Community Nutrition, Faculty of Human Ecology, Bogor Agricultural University.

Marshall W E. 1994. Starch Gelatinization in Brown and Miled Rice: A Study Using Differential Scanning Calorimetry. *In*: Marshall W E, Wadsworth J I. Rice Science and Technology. United States Department of Agriculture, New Orleans: 205–225.

Nutrition Directorate of the Ministry of Health. 1996. List of Food Composition. Jakarta, Indonesia: Bhratara Niaga Media Press.

Putri A S. 2012. Physical, chemical and sensory characteristics of rice retrogradation. Indralaya, Indonesia: Study Program of Agricultural Technology. Department of Agricultural Technology, Faculty of Agriculture, Universitas Sriwijaya.

Setyono A, Wibowo P. 2008. Selection of quality rice relationship with the characteristics of several strains of inbred and hybrid rice. *Nat Sem Rice*: 1525–1534.

Slaton N, Blocker M, Wilson C, Dilday R, Robinson J, Koen B. 2000. Grain Characteristics of Rice Varieties. Arkansas, USA: Department of Agriculture and County Govemments Cooperating, University of Arkansas Division of Agriculture.

Sudana W. 2005. Potential and prospect of wetlands as a source of agricultural production. *Agric Policy Anal*, **3**(2): 141–151.

Sudarmadji S, dan Suhardi B H. 2007. Analysis Procedures for Foodstuff and Agriculture. Yogyakarta, Indonesia: Liberty Press.

Sutarjana J. 2009. Heritage Culinary Mistress of the House: 1200 Legendary Recipes and Snacks. Jakarta, Indonesia: Gramedia Pustaka Utama Press.

Syafutri M I. 2015. Characteristics of Swamp Rice in South Sumatera, Indonesia. Indralaya, Indonesia: Universitas Sriwijaya.

Wahyudi T. 2005. Assessment of Physical, Chemical and Organoleptic Quality of Rice with Several Rice Varieties. Indralaya, Indonesia: Department of Agricultural Technology Faculty of Agriculture, Universitas Sriwijaya.

Winarno F G. 2004. Food Chemistry and Nutrition. Jakarta, Indonesia: Gramedia Pustaka Utama Press.

Yadav R B, Khatkar B S, Yadav B S. 2007. Morphological, physicochemical and cooking properties of some Indian rice (*Oryza sativa* L.) cultivars. *J Agric Technol*, **3**(2): 203–210.

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