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Milling Quality Assessment of Red Rice through Several Milling Processes in Yogyakarta Special Province

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In Yogyakarta Special Province at this time developing a simple small rice mill, with machine configuration consists of huskers and polisher with milling quality that is still not satisfactory. In order to improve the milling quality, the assessment of three different rice milling processes was undertaken. The objective of this study was to assess the milling quality of red rice through three different rice milling processes. The study was conducted in the rice mill of Gapoktan (Farmer Group Association) of Widodo Manunggal in Widodo Martani village, Sleman district, Yogyakarta Special Province in 2016. The study design was used complete randomized design (CRD) with three replications. The treatment of the milling process is 1) the milling process with the use of a one-time seed cleaner and three times husker, 2) three-times husker, and 3) a three-time husker using a blower). The red rice varieties used is Inpari 24 Gabusan. Statistical analysis used is Analysis of Variance (Anova) using Statistical Analysis System (SAS) program version 9.1, followed by Duncan Multiple Range Test (DMRT). The results showed that the milling process using seed cleaner followed by three times husker resulted in brown rice with percentage of head rice (96,16%) significantly better than that without seed cleaner with three times husker (91,72%), and three-times husker process using a blower (94.88%).Those brown rice has fulfilled in quality class I (minimum 95%) of Indonesian National Standar of Rice No 6128:2008. Red Rice Inpari 24 Gabusan has an antocyanin content amounted of 143 ppm that acts as an antioxidant.

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Introduction

One of the new superior varieties of red rice that has been released by the Ministry of Agriculture in 2012 is Inpari 24 Gabusan. Inpari 24 Gabusan derived from Bio 12-MR-1-4-PN-6 and local red rice origin from Brebes, Central Java (Badan Litbang Pertanian, 2013). Generally, red rice varieties superior in nutritional quality and functional properties compared to white rice, and some varieties also have other advantages of delicious taste and soft cooked rice. According to Sompong et al., (2011) the phytochemicals content in red rice has a good effect in preventing the occurence of degenerative diseases such as heart diseases and cancer. Red rice has the potential as a source of antioxidants and as a raw material for the development of functional foods (Yawadiao et al 2007; Tengah et al., 2011).

Muntana and Prasong (2010) report that phenolic compounds are associated with pigment content such as red, purple and black. Due to the increasing prevalence of degenerative diseases, the need for brown rice increases with the increasing consumer demand. In general, red rice is consumed by the consumers who have consious in nutrition, and most come from the middle to upper economy class in the community. Indrasari and Adnyana

(2007) reported that 38% of 86 respondents which is visited in Bali province reported that consuming local red rice daily, 16% respondents consuming more than six months and consuming 3-6 months.

The arrangement of rice milling machine (configuration) has an effect on the yield of milled rice and the quality of milled rice. The yield of milled rice produced by a small rice miller (SRM) with a simple configuration of Husker-Polisher (H-P) averaged 55.71% with 74.25% of head rice and broken rice 14.99%. While medium-scale paddy mill (MPM) with Cleaner-Husker-Separator-Polisher (CHSP) configuration resulted in yield, quality of rice (head rice and broken rice) respectively 59.69%, 75.73% and 12.52% (Dede, 2009).

The quality of milled rice is said to be good if the milling process is obtained with a lot of head rice with minimal broken rice. Milled quality is also determined by the amount of milled rice or yield produced. Milled quality is very closely related to the economic value of rice. One of the obstacles in rice production is that the amount of broken rice when milled, this can cause the quality of rice to decline.

Red rice has a layer of aleurons that contain phytochemicals, including anthocyanins that are beneficial to health and when millingit will lose some of its anthocyanin content. The most common types of

anthocyanin are cyanidin-3-O-glucoside and peonidin-3-O-glucoside (Lee, 2010). Park et al., (2008) reported that the anthocyanin content in black rice from Korea, Heugjinjubyeo was about 95% cyanidin 3-O-glucoside and 5% peonidin 3-O-glucoside. Therefore, red rice is consumed by removing the husk alone or known as brown rice of red rice. Therefore, this study aims to study the milling quality of red rice through three different rice milling processes.

Materials and Methods

The research was conducted in rice mill of Gapoktan (Farmer Group Association) of Widodo Manunggal, Widodo Martani, Ngemplak, Sleman, Rice Quality Laboratory at Indonesian Center for Rice Research (ICRR) and Food Technology Laboratory Gajah Mada University, Yogyakarta in 2016. Inpari 24 Gabusan paddy obtained from the farmers of Gapoktan Widodo Manunggal, Widodo Martani, Ngemplak, Sleman.

The identification of grain physical quality includes moisture content, grain density, empty grain, green grain + chalky grain, yellow grain + damaged grain, and 1000 grain weight (Graham, 2002). Inpari 24 Gabusan grains are then processed into brown rice through three different types of milling, namely 1x seed cleaner - 3x husker, without seed cleaner - 3x husker, and regular milling (common in the field) 3x husker - 1x blower.

The brown rice from the best milling results was analyzed the physical quality, milling quality, physicochemical properties, nutritional and functional quality. Analysis of physical quality of rice includes moisture content (oven method) and rice shape. Analysis of rice milling quality includes percentage of head rice, percentage of broken rice, and percentage of groats (Graham, 2002). Physicochemical properties analyzed were amylose content (IRRI, 1996), gel consistency (Cagampang et al., 1973 in Cruz and Khush, 2000), and gelatinization temperature (Little et al., 1958 in Cruz and Khus, 2000). While the nutrition and functional quality analyzed consist of protein content (micro Kjeldahl), fat (Soxhlet extraction), carbohydrate (by difference), energy (calculated based on the sum of multiplication of protein, fat and carbohydrate with each factor 3.41, 8.37 and 4.12 (Persatuan Ahli Gizi Indonesia, 2009) and anthocyanin content with pH difference method (Giusti (2000).

Data were analyzed using analysis of variance test followed by DMRT test if there were differences. SPSS 14.0 software is used for the test.

Results and Discussion

Physical quality of Inpari 24 Gabusan paddy

Compared with Indonesian National Standard (SNI) 0224-1987/SPI-TN/ 01/01/1993 on grain quality, the moisture content of Inpari 24 Gabusan (11.0 %), Aek Sibundong (11.90 %) and Sembada Merah (11.25 %) have met the

requirements under 14% (Indrasari et al., 2015). Moisture content is the percentage of moisture content of a substance which can be expressed on a wet basis or on a dry basis. Wet weight moisture content has a theoretical maximum limit of 100 percent, whereas moisture content based on dry weight can be more than 100 percent.

Grain moisture content is the ratio between the moisture weight in the sample and the initial weight of the sample. Grain moisture content greatly affects grain milling process. If the moisture content in the grain is high or more than 14%, the rice is soft, so that during milling process will cause the rice to be broken. If the moisture content in grain is less than 14% or equal to 14% then the grain will be stronger when milled. In addition, if the moisture content of the grain is more than 14%, it will facilitate microorganisms to live and multiply, causing decay during storage.

Table 1. Paddy quality of Inpari 24 Gabusan

Physical Quality	Moisture Content (%)	Empty Grain (%)	Paddy Density (g/l)	1000 Grain Weight (g)	Green + Chalky Grain (%)	Yellow+ Damaged Grain (%)
Inpari 24 Gabusan	11.0	13.52	490.5	25.65	0.52	2.06
Aek Sibundong*	11.90	2.65	564.0	23.23	1.84	0.82
Sembada Merah*	11.25	1.88	551.5	25.57	0.38	0.43

* Indrasari et al., 2015

Percentage of empty grain of Inpari 24 Gabusan sample is high enough (13.52%) that above of grade III (maximum 3%), while Aek Sibundong (2.65%) fulfilled grade III (maximum 3 %) and Sembada Merah (1.88%) fulfilled grade II (maximum 2 %) (Indrasari et al., 2015). The paddy density of Inpari 24 Gabusan (490.5 g /l), Aek Sibundong (564.0 g/l), and Sembada Merah (551.5 g/l) are in the range of paddy densities in Indonesia that is 454.4 to 577.0 g/l (Suismono et al., 2003). While the 1000 grains weight of Inpari 24 Gabusan is 25.65 g, Aek Sibundong is 23.23 g, and Sembada Merah is 25.57 g (Indrasari et al., 2015). Grain density and 1000 grain weight have an effect on the yield of milled rice (MR) and of brown rice (BR). Grain density and 1000 grains weight will result in greater yield of milled rice.

The 1000 grains weight is the weight of the ratio of 1000 grains produced by a grain variety. The 1000 grains weight in a variety has correlation with several other properties in crop productivity such as panicle length and number of grains per panicle. The 1000 grains weight in rice is high if the weight of 1000 grains reached over 30 g, while if under 30 g it is said low. One application for the use of 1000 grains weight is to determine the need for seeds in one hectare.

The percentage of green grain+chalky grain of Inpari 24 Gabusan (0.52%) and Sembada Merah (0.38 %) included in grade I (maximum 1%), while Aek Sibundong (1.84 %)

included ingrade II (maximum 5%) (Indrasari et al., 2015). Green grain or chalky grains are brown rice (after shelled) chalky white and soft texture caused by young seeds because harvest age is not optimal or due to poor growth and can also be caused by genetic factors. Green grain and chalky grains are not favored by milling consumers, as they produce white chalky rice. In addition, the green grain and chalky grains are easily damaged by pest attacks so that their storage capacity becomes low. The percentage of yellow+damage grain of Inpari 24 Gabusan (2,06 %) included in grade II (maximum 5%), while Aek Sibundong (0.82 %) and Sembada Merah (0.43 %) included in garde I (maximum 2%)(Indrasari et al., 2015).

Milling quality of inpari 24 Gabusan with 3 types of milling

The results of statistical analysis showed that there was a difference in the quality of milled rice produced at percentage of head rice, broken rice, groats, green grains + chalky, and yellow grains + damaged of Inpari 24 Gabusan brown rice (BR) rice from three types of milling. The percentage of head rice, broken rice of brown rice Inpari 24 Gabusan which milling with seed cleaner is better than that milling without seed cleaner and regular milling. The percentage groats of Inpari 24 Gabusan brown rice with seed cleaner equal to regular milling but lower than that milling without seed cleaner. The percentage of green grain+chalky and yellow grains + damaged grain of Inpari 24 Gabusan brown rice with seed cleaner and without seed cleaner better than that of regular milling (Table 2).

The highest percentage of head rice in Inpari 24 Gabusan brown rice is with seed cleaner (96,16%) and the lowest without seed cleaner (91,72%). Head rice is a component of physical quality of rice that directly affects the level of consumer acceptance. Milled rice with high head rice content is preferred to consumers rather than low. Head rice is a good, healthy, or defective rice that has a size greater than or equal to 6/10 parts of the average length of whole rice.

Based on Indonesian National Standard or SNI No.01-6128-2008 the quality of rice is divided into 5 grade (BSN, 2008). The percentage of head rice of Inpari 24 Gabusan with seed cleaner (96.16%) fulfilled grade I (minimum 95%), whereas without cleaner (91.72%) and the regular milling (94.88%) fulfilledgrade II (minimum 89%) (Table 2). Meanwhile, the percentage of broken rice of Inpari 24 Gabusan with seed cleaner (3.61%) fulfilled grade I (maximum 5%), while those without seed cleaner (7.43%) and regular milling (4.88%) fulfilled the quality grade II (maximum 10%) (Table 2). In the contrary to the percentage of head rice, the high percentage of broken rice causes the level of consumer acceptance to decline, as consumers are interested in the good rice shape. The higher percentage of broken rice and groats will cause the economic value of rice to decrease.

The broken grains are either healthy or defective rice grains that are smaller in size than ¾ part but smaller than 0.60 parts of the average length of whole grains of rice. One of the factors causing the high broken rice is the high level of moisture content of paddy is too low. Fractional surfaces are very susceptible to warehouse pests, both microorganisms and insects. So the number of broken rice will increase the possibility of attack by the pest warehouse.

Table 2. Milling Quality of Inpari 24 Gabusan (BR) with 3 types of milling

Milling Types	Moisture Content (%)	Head Rice (%)	Broken Rice (%)	Groats (%)	Green Grain+ Chalky (%)	Yellow Grain +Damaged (%)
Without Seed Cleaner	10,55c	91,72c	7,43a	0,84a	0,97b	1,14 b
With Seed Cleaner	10,75b	96,16a	3,61c	0,23b	0,84b	1,48 b
Regular Milling	10,85a	94,88b	4,88b	0,26 b	1,19a	2,43 a

The numbers followed by the same letter show no significant difference in α 5%

Table 3. Physical Quality ofInpari 24 Gabusan with Two Other Red Rice

Physical Quality	Moisture Content (%)	Length (L) (mm)	Width (W)(mm)	Ratio L/W
Inpari 24 Gabusan	10.65	7.24	2.20	3.31
Aek Sibundong*	10.00	6.97	2.29	3.04
Sembada Merah**	12.5	6.48	2.46	2.75

* Indrasari, 2006; ** Indrasari et al., 2015

While the groats is broken rice grains, both healthy and defective that has a size smaller or equal to 0.25 parts of whole grains of rice. The percentage of groats of Inpari 24 Gabusan with 3 different types of milling is fulfilled grade II (maximum 1%) (Table 2).

Table 4. Physicochemical Properties of Inpari 24 Gabusan

Variety	Amylosa (%)	Gel consistency		Gelatinization Temperature	
		mm	Explanation	Score	°C
Inpari 24 Gabusan	13.7	66	Soft	6	<70
Aek Sibundong*	21.90	84	Soft	5	>74
Sembada Merah**	18.6	41	Medium	5	70-74

* Indrasari et al., 2008; ** Indrasari et al., 2015

The percentage of chalky grains is another component of the milling quality that determines the consumer's preference. In Table 2 it can be seen that the percentage of Inpari 24 chalky grains with seed cleaner and without seed cleaner are the same but different from those regular milling (Table 2). Based on the criteria of the quality of the chalky grains, Inpari 24 Gabusan with seed

cleaner (0.97%) and without seed cleaner (0.84 %) meet the grade II (maximum 1%), while Inpari 24 Gabusan with regular milling (1.19 %) meets grade III (maximum 2%) (Table 2). Generally consumers do not like milled rice with high chalky grain content. This is because chalky grains easily invested by pests at the time of storage thereby reducing the shelf life of rice. One of the factors that cause the high chalky grain is less optimal harvest time, causing green grain and when milled produces white chalky rice.

The percentage of broken yellow grains of Inpari 24 Grains with seed cleaner (1.14 %) and without seed cleaner (1.48%) meet grade III quality (maximum 2%), while those with regular/ordinary milling (2.43%) meet grade IV quality (maximum 3%). The damaged yellow grain is a pure yellow-and-yellow-brown rice grain due to the color changes that occur during processing. Analysis of yellow and broken grains can be done directly by looking at the physical grains of grain. Yellow grains are usually shown by paddy grains that yellow faded or reddish, usually overgrown with mushrooms on the skin. The yellow color of the grain is mainly due to fermentation, decay, and fungal growth. These processes are caused by the imperfect grain drying process after harvest.

Table 5. Nutritional and Functional Quality of Inpari 24 Gabusan

Variety	Protein (%)	Fat (%)	Carbohydrate (%)	Energy (calori)	Anthocyanin (ppm)
Inpari 24 Gabusan	8.3	2.47	87.55	416.5	143
Aek Sibundong*	9.0	0.37	74.60	383.95	154.4

* Indrasari et al., 2008

Physical quality of Inpari 24 Gabusan rice

Based on Table 3 it is known that the length and width ratio of Inpari 24 Gabusan, Aek Sibundong and Sembada Merah are 3.31, 3.04 and 2.75 consecutively (Indrasari, 2006 and Indrasari et al., 2015). The ratio of length and width of rice determines the classification of the shapes of the rice. According to Juliano (1993) the International Rice Research Institute classifies rice into 4 types: slender (long and lean) (> 3.0), medium (2.1-3.0), bold (short slightly oval) (1,1-2,0), and round (round) (<= 1). Based on the classification, the shape of Inpari 24 Gabusan and Aek Sibundong rice are slender (long and lean) and sembada merah is medium (Indrasari, 2006 and Indrasari et al., 2015). In general, consumers prefer rice with slender shape. The shape, size, weight and uniformity of seeds is an important factor in the rice industry. The rice dimension determines in the international market because long grain rice has a high demand (Damardjati and Purwani, 1991). In addition, information on the ratio of length and width is required in determining the drying and processing equipment.

Physicochemical Properties of Inpari 24 Gabusan

The texture of cooked rice is closely related to the amylose content of rice. Juliano (1993) divides amylose into 4 groups: very low amylose (<10%) results in glutinous rice, low amylose (10-20%) results in very soft cooked rice, medium amylose (20-25%) produces soft cooked rice and amylose (> 25%) produces hard cooked rice. The result of the amylose content of Inpari 24 Gabusan (13.7 %) and Sembada Merah (18.6 %) are included in low amylose grade that produced a very soft cooked rice texture (Indrasari et al., 2015). Aek Sibundong is included in medium amylose that produced soft cooked rice (Table 4) (Indrasari et al., 2008).

The consistency of the gel is measured by the consistency of rice paste. Rice is grouped into 3 groups based on the consistency of the gel, ie consistency of hard gel (very flaky rices) with gel length ≤ 40 mm, rice with flaky rices consisting of gel length 41-60 mm, and rice with low gel consistency (soft rices) with gel length ≥ 61 mm (Cruz and Khush, 2000). Based on the classification, Inpari 24 Gabusan (66 mm) and Aek Sibundong (84 mm) cooked rice includes rice with soft rices (> 61 mm), while Sembada Merah (41 mm) cooked rice includes rice with medium rice (Table 4) (Indrasari et al., 2008 and Indrasari et al., 2015).

Gelatinization temperature is the temperature when 90% of starch granules are irreversible, lose their crystalline shape, and loss of it birefringence properties. Gelatinization temperature will be achieved if the starch is heated with the addition of water. The time to get the gelatinization temperature is usually used to determine the length of cooking time. Temperature of gelatinization of starch ranges between 55-79°C, depending on the type of plant and varieties (Cruz and Khush, 2000). Rice with high gelatinization temperature is less expanding if cooked than rice with medium and low gelatinization temperature (Suismono, 2003). Environmental conditions of rice can affect gelatinization temperature. One of the environmental factors that affects is temperature. The process of ripening of paddy grain that occurs at high temperatures will produce higher gelatinization of rice (Cruz, et al., 1989 in Cruz and Khush, 2000). Determination of starch gelatinization temperature in this study was by using alkali test method.

Rice is classified into 3 groups based on its gelatinization temperature, ie low gelatinized (<70°C) rice, medium gelatinization (70-74°C) rice, and high gelatinization (> 74°C) rice. Based on the classification, Inpari 24 Gabusan (<70°c) include rice with low gelatinization temperature, while Aek Sibundong (>74°c) include rice with high gelatinization temperature and Sembada Merah include rice with medium gelatinization temperature (70-74°c) (Table 4) (Indrasari et al., 2008 and Indrasari et al., 2015).

Nutritional and functional quality of Inpari 24 Gabusan

The nutrient content and functional qualities of Inpari 24 Gabusan and Aek Sibundong are shown in Table 5. The content of protein, fat, carbohydrate and energy of Inpari 24 Gabusan respectively are 8.3%, 2.47%, 87.55%, 416.5 calories and Aek Sibundong are 9.0 %, 0.37 %, 74.60 % an 383,95 calories consecutively (Indrasari et al., 2008). While the average content of protein, fat, carbohydrate and energy of milled rice in Indonesia are respectively 7.82%, 0.80%, 90.69% and 413.86 calories (Persatuan Ahli Gizi Indonesia, 2009).

Anthocyanins include flavonoid components, ie polyphenol derivatives in plants that have antioxidant capabilities (Takamura and Yamagami, 1994; Wang et al., 1997) and anticancer (Karainova, et al., 1990; Kamei et al., 1995). Antosianin is also used as an indicator of the quality of food (Giusti, 2000). The anthocyanin content of Inpari 24 Gabusan is 143 ppm lower than that of Aek Sibundong red rice (154.4 ppm), red rice line of B11844-9-9-5 (205.9 ppm), B 11844-7-17-3 (190.7 ppm), B10970C-MR-4-2-1-1-1 SI-3-2-4-1-PN-4 (214.2 ppm), B1002E-MR-2 (171.1 ppm) (Indrasari et al., 2013). While Tengah et al., (2011) reported that the highest total anthocyanin content in rice bran of Cendana variety from Tabanan, Bali, obtained with 36 hours maceration time using acidified solvent was 109.33 mg / 100 g.

Conclusions

The milling process of Inpari 24 Gabusan using seed cleaner followed by three times husker resulted in brown rice with percentage of head rice (96,16%) significantly better than without seed cleaner with three times husker (91,72%), and three-times husker process using a blower (regular milling) (94.88%). The brown rice of Inpari 24 Gabusan has fulfilled in quality grade I (minimum 95%) of Indonesian National Standar of Rice No 6128:2008. The shape of Inpari 24 Gabusan is slender and the texture of cooked rice is very soft. The protein content of Inpari 24 Gabusan is 8.3% and the antocyanin content amounted of 143 ppm that acts as an antioxidant.

Conflict of Interest

All the authors declare that they have no conflict of interest.

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