Comparison of Physical Properties, Proximate Composition and Milling Quality of Rice Grains from Different Branches within a Panicle

Rizky Tirta Adhiguna, Sutrisno, Sugiyono, Ridwan Thahir

Abstract— The physical properties, proximate compositions and milling quality of rice grain from different branches within a panicle were compared. Two rice varieties, Sintanur (medium grain) and IPB-4S (long grain) were cultivated. At full maturity, the physical properties, proximate compositions and milling quality of rice grains from different branches within a panicle were studied. There were significant differences in grain dimensions, volume, thousand grain mass, bulk density, moisture, crude fat, crude protein, crude fiber, head rice yield, broken rice yield (large and small broken) and grain hardness of the rice grains among primary and secondary branch within a panicle for all two varieties, but no differences were found for shape, ash and grain whiteness. Bulk density, moisture, broken rice yield and whiteness tended to be lower in the rice grains from primary branch than in those from the secondary branch, and the other parameters showed the opposite trend for all two varieties. The differences of physical properties, proximate composition and milling quality studied in this papers are necessary information used in processing operations of rice grainand will provide a guide to geneticist and breeders seeking to develop varieties of rice.

Index Terms— Rice grain, branches, physical properties, proximate composition, milling quality.

1 Introduction

Rice is consumed as staple food of Indonesian population and by almost half of the Southeast Asia population. The most important quality components encompass appearance, milling quality, cooking and nutritional quality [1]. Physical properties of rice grains determine the appearance and milling quality. Physical properties of rice grains include size, shape, volume, thousand-kernel weight and bulk density [2]. Proximate composition determines the basic cooking and nutritional quality. Proximate composition of rice grains includes moisture, ash, crude protein, crude fat dan crude fiber [3, 4].

Rice grain quality is affected by many factors during plant growth.Variation of flowering spikelets located at different positions within a panicle is considered as one of the major factors causing differences weight and quality among rice grains [5]. The early-flowering spikelets which are regarded as superior spikelets (rice grains) have higher filling rate and complete development, compared with late-flowering spikelets (referred to as inferior spikelets) [6].

The complete information of physical properties and proximate composition of rice grains are of fundamental importance during the design and manufacturing different types of equipment used in processing and cooking operations of rice grain.

The differences in physical properties, proximate composition, and milling quality have a guiding role in improving the grain quality through breeding approaches. In Indonesia, there is a lack of information on the rice grain properties and quality from different branches within a panicle. This study aimed to determine the differences of physical properties, proximate composition and milling quality of rice grains from different branches within a panicle.

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2 Research Method

2.1 Time and Location

Time and Location was carried out from June 2015 to February 2016. Location of research was the experimental farm of Muara, laboratory of Great Hall of Post Harvest Research and Development of Agriculture, laboratory of PAUBTI and laboratory of Biosystem of Department of Mechanical and Biosystem Engineering, Bogor Agricultural University.

2.2 Material and Equipment

Two rice varieties-Sintanur (medium grain) and IPB-4S (long grain)-were cultivated in the experimental farm. Plot dimension was 6 m x 8 m for each variety. Two thousand panicles were chosen and tagged for each plot [6]. Each panicle was divided into different samples according to rice grain from the primary and secondary branch within a panicle. The cultivation was managed according to the locally recommended agronomic practices. All varieties were harvested at maturity (34 days after heading) Rice grain samples were hand threshed.

Equipments used in this research were digital caliper to an accuracy of 0.01 mm, oven, desiccator, digital weighing scale (AQT-200), oven, rice husker (Satake THU-35A), rice polisher (Satake TM-05), drum grader (Satake TRG-05A), milling meters (Satake MM-1C), Kiyagrain hardness tester (Fujiko Seisakusho LTD),scanning electron microscope (EVOIMA10, ZEISS) operating at 10 kV.

2.3 Research Procedure

Research was started by threshing the rice grains from the primary and secondary branch within a panicle in two varieties. One thousand rice grains samples from each group were randomly selected and the length, width, thickness determined using digital caliper [7]. Grain shape (L/W) was derived by the ratio of length to width [8]. The volume of an ellipsoid [(π/6) x length x width x thickness) was used to approximate grain volume [8].

One hundred rice grains samples from each group were determined by counting 1000 rice grains and weighed separately in a digital weighing scale [9]. Bulk density was measured using the AOAC method [10], in which a 50 ml cylinder was filled with rice grain from a height of 15 cm. The excess rice grain was removed and the weight recorded. The bulk density was then calculated as the ratio of rice grain weight to the volume occupied [11].

Proximate compositions (moisture, ash, crude protein, crude fat, and crude fiber) of rice grains samples from each group as described above were quantified using standard AOAC methods [10].

Rice grain samples from each group were sun dried until a moisture content of about 14% was attained [7]. The dried rice grains were dehusked in a THU-35A Satake Rice Husker. The brown rice was milled using a TM-05 Satake Rice Polisher. Milled rice samples from each group were weighed before being separated into head and broken rice. Weights of head rice and broken rice samples from each group were obtained and percentages of head milled rice and broken milled rice were calculated. Grain milling quality was tested according to the National Standard of the Republic of Indonesia [12].

Grain hardness was measured using a Kiya grain hardness tester [7]. Ten grains were used in the determination of hardness for each group. The handle of the equipment was initially turned anti-clockwise to make room to place a grain on the sample table. The handle was turned clockwise until a cracking sound was heard. The black point returns to the zero point and the red point remained. The reading of the red point (kg) indicated the hardness of the grain.

The whiteness of milled rice was determined using Satake milling meter [7]. The Satake milling meter was calibrated using standard white and brown plates. The sample case was filled with grains and placed in the sample inlet port. The values of whiteness displayed on the screen were recorded.

Rice starch powder were sprayed directly on to carbon specimen stubs. The specimens were sputter coated with gold (Q150R ES, Quorum) and view with a EVOIMA10 (ZEISS) operating at 10 kV.

The data were analyzed using analysis of variance processed with STAR version 2.0.1 (IRRI) with differences considered significant when $P < 0.05$. Means separation was carried out by least significant difference (LSD).

3 Result and Discussion

3.1 Physical Properties of Rice Grains

Grain size and grain shape are among the first rice quality criteria that breeder considers when developing new varieties for release and for commercial production [13]. At maturity, the mean value for grain dimensions (length, width, and thickness) of the investigated rice grains at the primary and secondary branch in two varieties (Sintanur and IPB-4S) are presented in table 1.

As shown in table 1, rice grains from the primary branch in two varieties had higher the grain dimensions compared to rice grains from the secondary branch. There was a significant difference in length, width, and thickness of rice grain between the primary and secondary branch for all varieties.

TABLE 1
PHYSICAL DIMENSIONS Of RICE GRAINS

Varieties	Branch	Length (mm)	Width (mm)	Thickness (mm)
Sintanur	Primary	8.69	3.47	2.55
	Secondary	8.26	3.36	2.44
IPB-4S	Primary	9.79	2.82	2.45
	Secondary	9.14	2.67	2.14

Rice grains from the primary branch in two varieties had higher the mean L/W compared to rice grains from the secondary branch (fig. 1). On the other hand, the mean L/W ratio was higher (3.47) for rice grains from the primary branch in IPB-4S variety compared to the mean L/W ratio for rice grains from the primary branch in Sintanur variety (2.50). The mean L/W ratio was higher (3.42) for rice grains from the secondary branch in IPB-4S variety compared to the mean L/W ratio for rice grains from the secondary branch in Sintanur variety (2.46). Length to width (L/W) ratios are used in the classification of grain shape, a higher value indicating slender shapes and a lower value indicating medium intermediate, bold or round shapes. Rice grains in IPB-4S variety had long-slender shapes while rice grains in Sintanur variety had medium-intermediate shapes. There was not a significant difference in the shape of rice grain between the primary and secondary branch for all varieties.

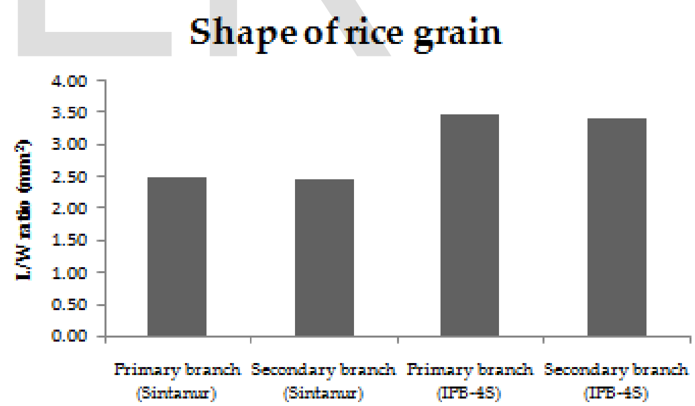

Fig. 1. Shape (L/W ratio) of rice grain

Variability in grains structure such as size and volume has a decisive influence on the rate and duration of grain filling [8].A volume is a relevant tool in determining the density of rice grains [2]. The volume of rice grains from the primary and secondary branch in two varieties is shown in figure 2. In this study, rice grains from the primary branch in two varieties had high volume. The volume of rice grains from the secondary branch in two varieties was lower. Rice grain from the primary branch in Sintanur variety had higher the volume (40.26 mm3) compared to the volume of rice grains from the secondary branch (35.46 mm3). Rice grains from the primary branch in IPB-4S variety had higher the volume (35.42 mm3)

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compared to the volume of rice grains from the secondary branch (30.56 mm3). There was a significant difference in volume of rice grain between the primary and secondary branch for all varieties.

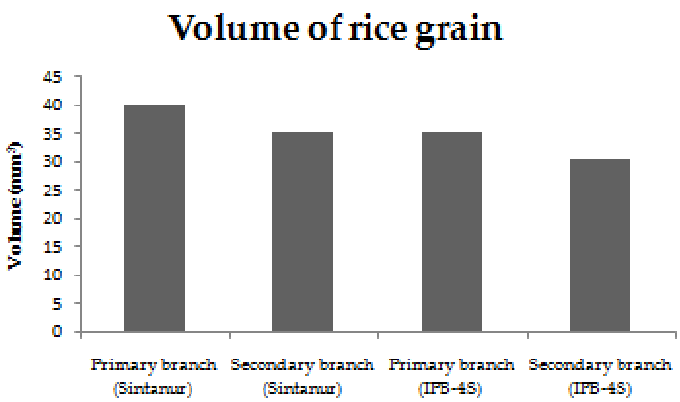

Fig. 2. Volume of rice grain

Weight values showed marked differences the varieties probably due to an intrinsic characteristic of each variety [15].Thousand grain mass is a measure of rice grains size and a range of 20-30 gr is acceptable. Below 20 gr indicates the prese nce of immature, damaged or unfilled grains [15]. Rice grains from the primary branch in two varieties had higher thousand grain mass compared to rice grains from the secondary branch. Thousand grain mass of rice grain from the primary and secondary branch in Sintanur variety were 24.98 mg and 24.16 mg, respectively. Thousands grain mass of rice grain from the primary branch were 28.43 mg and 26.91mg for the thousand grain mass of rice grain from secondary branch in IPB-4Svariety. There was a significant difference in thousand grain mass of rice grain between the primary and secondary branch for all varieties.

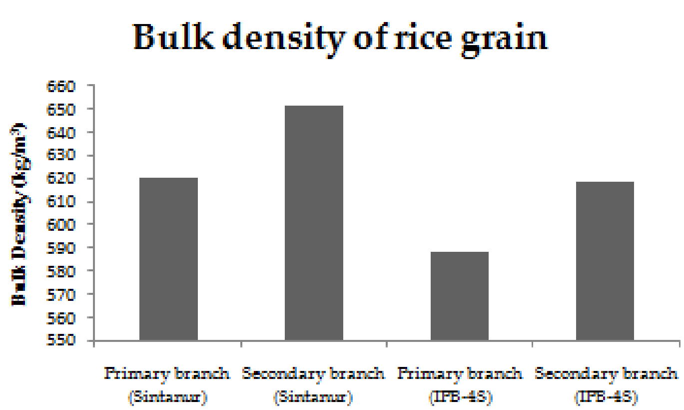

Fig. 3. Bulk density of rice grain

The bulk density is one of the basic parameters for using in sizing grain hoppers, storage facilities and affect others parameters during aeration and drying processing. The bulk density is correlated with a moisture content of rice grains [15]. The bulk density of rice grain from the primary and secondary branch in two varieties is shown in figure 3. Rice grains from the primary branch in two varieties had lower the bulk density compared to rice grains from the secondary branch. Rice grain from the primary branch in Sintanur variety had lower the bulk density (620.58 kg/m3) compared to the bulk density of rice grains from secondary branch (651.34 kg/m3). Rice grains from primary branch in IPB-4S variety had lower the bulk density (588.46 kg/m3) compared to the bulk density of rice grains from the secondary branch (618.56 kg/m3). There was a significant difference in bulk density of rice grain between the primary and secondary branch for all varieties.

3.2 Proximate Compositions of Rice Grains

The amount of ash content plays an important role while determining the levels of essential minerals [4]. Ash content of rice grain from the primary and secondary branch in Sintanur variety were 6.85% and 6.54%, respectively. Ash content of rice grain from primary branch was 6.86% and 5.85% for ash content of rice grain from the secondary branch in IPB-4S variety. There was not a significant difference in ash content of rice grain between the primary and secondary branch for all varieties.

Rice grains with early maturity generally exhibit a higher level of protein content compared with late maturity [16]. Protein content of rice grain from the primary and secondary branch in Sintanur variety were 6.60% and 6.04%, respectively. The protein content of rice grain from the primary and secondary branch in IPB-4S variety were 7.13% and 6.40%, respectively. There was a significant difference in crude protein of rice grain between the primary and secondary branch for all varieties.

Crude fat content is suspected that the increased in crude fat content was a result of the increase in grain dimension [17].The crude fat content of rice grain from the primary and secondary branch in Sintanur variety were 2.18% and 2.03%, respectively. The crude fat content of rice grain from the primary and secondary branch in IPB-4S variety were 2.07% and 1.97%, respectively. There was a significant difference in the crude fat of rice grain between the primary and secondary branch for all varieties.

The highest percentage of crude fiber could be said to be a good quality trait because rice is a good source of insoluble fiber [18]. Crude fiber content of rice grain from primary and secondary branch in Sintanur variety were 8.24% and 7.03%, respectively. Crude fiber content of rice grain from the primary and secondary branch in IPB-4S variety were 8.89% and 7.96%, respectively. There was a significant difference in the crude fiber of rice grain between the primary and secondary branch for all varieties.

Moisture content has a clear influence on all aspects of rice grain quality. As rice grain matures on a panicle, it has variable moisture content representing various maturity and strength levels [19]. At a high moisture content, energy expenditures are high because much moisture must be removed before the rice grains be milled [20]. Like rice grains density, the finding of this study showed that rice grains from the primary branch in two varieties had lower moisture compared to the rice grains from the secondary branch. The moisture of rice grains from primary and secondary branch in Sintanur variety were 21.28% and 23.83%, respectively. The moisture of rice grains from the primary and secondary branch in IPB-4Svariety were 18.22% and 22.34%, respectively. There was a

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significant difference in moisture of rice grain between the primary and secondary branch for all varieties.

3.3 Milling Quality of Rice Grains

Rice is mainly used as milled by removing the hull and bran layers of the rice grains in the dehulling and milling processes, respectively [21]. Head rice yield is the weight of head grain or whole kernel in the rice lot. Large broken rice category describes milled rice with length less than three-quarters but more than one-quarter of the average length of the whole kernel. Small broken rice category described milled rice with length less than one-quarter of the average length of the whole kernel.

High head rice yield is one of the most important criteria for measuring milled rice quality. Head rice yield typically varies with the moisture content at which rice grain is harvested [22]. Rice from the primary branch in two varieties had higher head rice yield compared to the rice from the secondary branch. Head rice yield from the primary and secondary branch in Sintanur variety were 81.33% and 66.94%, respectively. Head rice yield from primary and secondary branch in IPB-4S variety were 83.46% and 80.33%, respectively. There was a significant difference in head rice yield milled of rice between the primary and secondary branch for all varieties

Broken rice reduces milling yield. Brokens produced during milling are generally the result of immature rice grains. Immature rice grains can be a source of milling quality reduction because these rice grains are typically weak in structure and often break during milling [23]. Rice from the primary branch in two varieties had lower broken rice (small/large) compared to the rice from the secondary branch. Broken rice (small/large) from primary and secondary branch in Sintanur variety were 1.68%, 16.99% and 4.10%, 28.96% respectively. Broken rice (small/large) from primary and secondary branch in IPB-4S variety were 0.67%, 15.87% and 18.81%, 0.86%, respectively. There was a significant difference in broken rice milled of rice grain between the primary and secondary branch for all varieties.

Grain hardness is an important factor in such diverse areas as changes during storage, drying and handling, processing and grain breakage during the milling process, kernel appearance includes whiteness [7]. Results of this study showed that rice from the primary branch in two varieties had higher values of grain hardness compared to the rice from the secondary branch.Grain hardness of rice from the primary and secondary branch in Sintanur variety were 5.90 kg and 5.70 kg, respectively. Grain hardness of rice from primary and secondary branch in IPB-4S variety were 6.30 kg and 6.15 kg, respectively. There was a significant difference in grain hardness of rice between the primary and secondary branch for all varieties.

Most consumers prefer white grains and are prepared to pay a premium [13]. The grain whiteness of rice from the primary and secondary branch in two varieties is shown in figure 4. For the sintanur variety, Rice from the primary branch in Sintanur variety had lower grain whiteness (45.14%) compared to grain whiteness for rice grains from the secondary branch (45.36%). Rice from the primary branch in IPB-4S variety had lower grain whiteness (45.26%) compared to grain whiteness for rice from the secondary branch (45.53%). There was not a significant difference in grain whiteness of rice between the primary and secondary branch for all varieties.

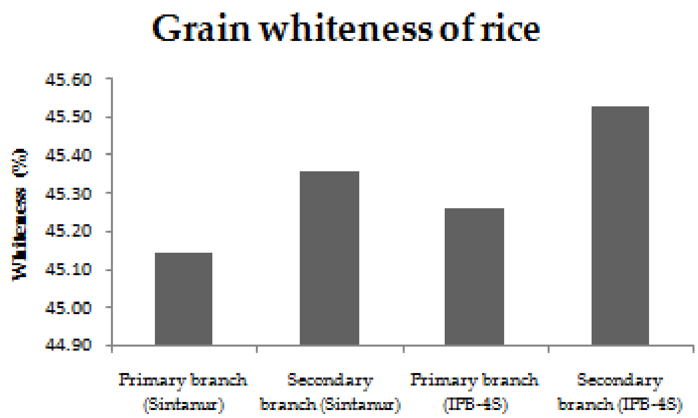

Fig. 4. Grain whiteness of rice

The diameters of starch granules (D) of rice grain from the primary branch (fig 5 and 7) were larger and so compact than those of rice grain from the secondary branch (fig 6 and 8).

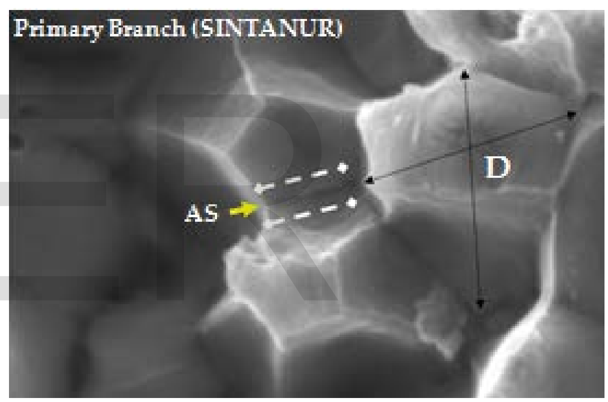

Fig. 5. SEM of starch granule of rice from the primary branch in Sintanur variety at 10000x (scala bar = 1 µm)

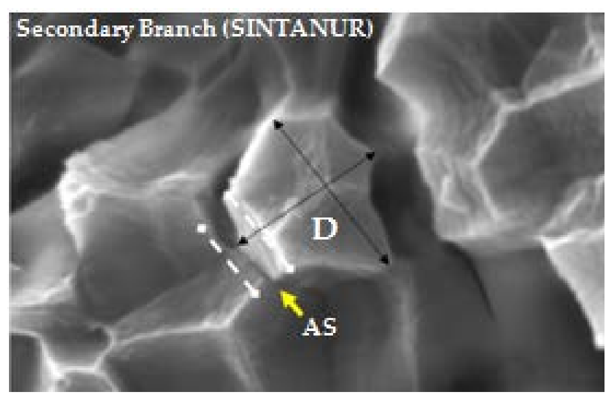

Fig. 6. SEM of starch granule of rice from the secondary branch in Sintanur variety at 10000x (scala bar = 1 µm)

The air space (AS) between individual starch granules within compound starch granules was larger for rice from the secondary branch (fig 6 and 8) than for rice grain from the primary branch (fig 5 and 7), which may have been responsible for relative opaqueness of rice grain from the secondary branch.

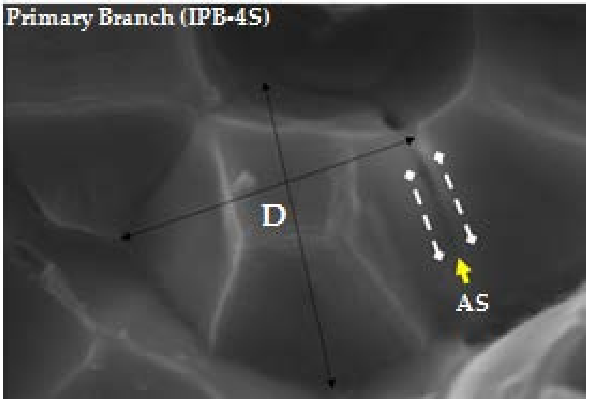

Fig. 7. SEM of starch granule of rice from the primary branch in IPB-4S variety at 10000x (scala bar = 1 µm)

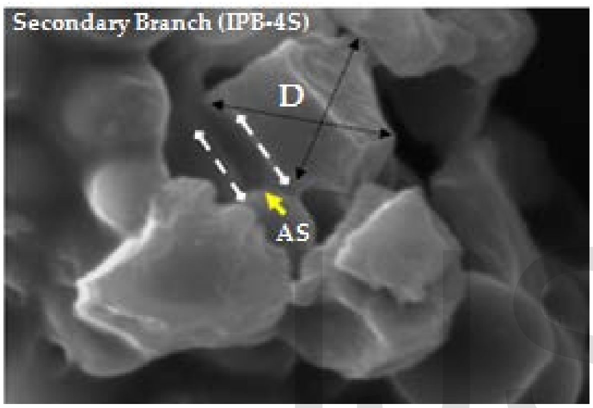

Fig. 8. SEM of starch granule of rice from the secondary branch in IPB-4S variety at 10000x (scala bar = 1 µm)

CONCLUSION

There were significant differences in grain dimensions, volume, thousand grain mass, bulk density, moisture, crude fat, crude protein, crude fiber, head rice yield, broken rice yield (large and small broken) and grain hardness of the rice grains among the primary and secondary branch within a panicle for all two varieties, but no differences were found for shape, ash and grain whiteness. Bulk density, moisture, broken rice yield and whiteness tended to be lower in the rice grains from the primary branch than in those from the secondary branch, and the other parameters showed the opposite trend for all two varieties. The diameters of starch granules of rice grain from the primary branch were larger and so compact than those of rice grain from the secondary branch. The differences of physical properties, proximate composition and milling quality studied in this papers are necessary information used in processing operations of rice grain and will provide a guide to geneticist and breeders seeking to develop varieties of rice.

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