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Physical properties on Indonesian local rice varieties

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Abstract. Rice is the main staple food for the people of Indonesia. It consists of some variation as its diversity. Each rice variety has a different physical shape and size in the grain. This study aims to determine the physical properties of several local Indonesian rice varieties. Research on the physical properties of grain was carried out on nine Indonesian local rice varieties from Banten, West Sumatra, and East Java provinces. Physical properties parameters observed in grain include length, width, shape, 1000 grain weight, bulk density, and chalkiness percentage of rice. The results showed that the grain shape of Tunggul Hideung and Genjah Nganjuk was slender and the other varieties were oval. While the type of Kewal Bulu Hideung includes round rice, the Kewal Bulu Hideung is slim in shape, and other varieties are oval. The highest 1000 grain weight in grain and rice was possessed by Kewal Gudril (28.23 g and 22.44 g), and the lowest was in Kuriak Kusuik (20.62 g and 14.09 g). The highest density of unhulled bulk density is Kuriak Kusuik (0.62 g.mL⁻¹), and the lowest is Kewal Bulu Hideung (0.3 g.mL⁻¹), while the highest rice bulk density is Susu Putih (0.89 g.mL⁻¹) and the lowest one is the Genjah Nganjuk (0.79 g.mL⁻¹). Based on the percentage of calcareous rice, Kewal Benur and Genjah Nganjuk including premium quality rice, Kewal Bulu Hideung, Tunggul Hideung and Kuriak Kusuik rice including medium quality class 1 rice, and other varieties do not meet the quality requirements set by SNI (> 5%).

Keywords: rice, grain, local rice, physical properties

1. Introduction

Rice is one of the primary food crops of almost half the world's population [1]. About 90% of the world's rice is grown and consumed in Asia [2]. Indonesian people has become the largest nation that consumes rice as a staple food and makes it a preeminent source of carbohydrates because it is easy to obtain, tastes good and can be combined with other food ingredients. According to [3], rice as a staple food contributes around 40-80% of energy and 45-55% of the protein in the average menu of the Indonesian people.

Rice (*Oryza sativa*) is also considered the most important cereal crop in the developing world. It is generally considered a semi-aquatic annual grass plant. About 20 species of the genus *Oryza* are recognized, but nearly all cultivated rice is *O. sativa* L. A small amount of *Oryza glaberrima*, a perennial species, is grown in Africa. So-called "wild rice" (*Zizania aquatica*), grown in the Great Lakes region of the United States, is more closely related to rice than to rice [4].



Since 2011 to 2017 rice production has continued to increase at 65.75 million tons in 2011 and 81.38 million tons in 2017. The achievements in 2017 have exceeded the rice production target set at 79 million tons [5]. National rice production in the period 2010-2017 continues to increase. In 2017 rice production is estimated to reach 81,382,451 tons, growing 2.56 percent from the previous year [6].

Indonesia has a vast genetic diversity of rice because the archipelago was formerly united with the Asian continent, which is the center of origin (center of origin) rice [7]. Rice germplasm in the form of varieties is very diverse, ranging from national varieties and local varieties. [8] reported that some rice-producing farmers in several regions in the Indonesian province still planted local varieties hereditary. According to [9], differences in varieties show significant differences in morphology, physical-chemistry, and cooking properties.

The marketing values of rice as an agricultural product depend on its physical qualities after the harvesting. Information on nutritional content and physical properties of rice are generally only found in superior varieties of rice. While rice on the market is very diverse in types and varieties, there is still little information related to the physicochemical nature of Indonesia's local rice germplasm. So it is deemed necessary to obtain primary data regarding the physical properties of local Indonesian rice for various purposes, especially for plant breeding activities. Based on this, it was necessary to research the physical properties of Indonesian local rice (*Oryza sativa* L.) varieties.

2. Method

This type of research is descriptive quantitative research. The research has been carried out in the biotechnology laboratory of Faculty of Agriculture, University of Sultan Ageng Tirtayasa and analyzed in laboratory of Faculty of Agriculture, University of Jember from October 2017 until February 2018.

The research began with the collection and identification of local rice variety from several regions in Indonesia. The local rice varieties used were Kewal Bulu Hideung, Kewal Gudril, Kewal Benur, Kewal Sampai Putih and Tunggul Hideung from the Banten region; Kusuik Kuriak from West Sumatra and MS Pendek, Susu Putih and Genjah Nganjuk from East Java. After collecting and searching for data on local rice varieties used including the date of harvest and the method of storing the local rice, the physical characteristics were analyzed, namely length, width, size, shape, the weight of 1,000 grains, density, and chalkiness..

3. Results and Discussion

3.1. Length, width and shape on grain and rice

Physical properties that are closely related to the quality of grain and rice and the level of consumer acceptance include grain size (length and width) and length and width ratio that reflects the shape of grain and rice. Classification of grain size and shape criteria is based on the SNI scale [10], and rice is based on the FAO scale [11].

Table 1. Average of length (L), width (W), the ratio of L/W, size, and shape of grain

Varieties	Length (mm)	Width (mm)	Ratio L/W	Size Grain	Form Grain
Kewal Bulu Hideung	8.01	3.38	2.37	Very long	Oval
Kewal Gudril	8.42	3.22	2.62	Very long	Oval
Kewal Benur	8.56	3.00	2.85	Very long	Oval
Kewal Sampai Putih	8,12	3.37	2.41	Very long	Oval
Tunggul Hideung	9.68	2.60	3.72	Very long	Slim
Kuriak Kusuik	8.05	2.75	2.93	Very long	Oval
MS Pendek	8.44	2.92	2.89	Very long	Oval

Varieties	Length (mm)	Width (mm)	Ratio L/W	Size Grain	Form Grain
Susu Putih	9.44	3.18	2.97	Very long	Oval
Genjah Nganjuk	9.54	2.88	3.31	Very long	Slim

All rice varieties studied have very long grain size with a length of more than 7.5 mm (Table 1). The layer of the husk primarily determines the length and shape of the grain. The longer and the larger size of the grain show the thicker layer of the husk that wraps the rice grains on the rice.

Table 2. Average of length (L), width (W), the ratio of L/W, size, and shape of rice

Varieties	Long (mm)	Wide (mm)	Ratio L/W	Size Rice	Form Rice
Kewal Bulu Hideung	5.61	2.81	1.99	Medium	Round
Kewal Gudril	5.67	2.74	2.07	Medium	Oval
Kewal Benur	6.08	2.45	2.48	Medium	Oval
Kewal Sampai Putih	5.76	2.70	2.13	Medium	Oval
Tunggul Hideung	6.50	2.10	3.10	Medium	Slim
Kuriak Kusuik	5.57	2.07	2.69	Medium	Oval
MS Pendek	5.71	2.21	2.58	Medium	Oval
Susu Putih	6.12	2.42	2.53	Medium	Oval
Genjah Nganjuk	6.79	2.33	2.91	Long	Oval

The size of the local rice studied was obtained in length ranging from 5.57 to 6.79 mm (Table 2). In general, rice in Indonesia is of medium to long size. Long sized rice is preferred on the international market compared to medium and short sized rice. However, in certain countries, short-sized rice is preferred in Japan, Korea, and Taiwan.

The width of rice obtained ranged from 2.07 to 2.81 mm. The widest rice is Kewal Bulu Hideung rice from Banten, while the rice with the smallest width is Kuriak Kusuik rice from West Sumatra. The length and width ratio of rice obtained ranged from 1.99 - 3.10. Based on the ratio of length/width, the shape of ground rice, according to FAO, is divided into three types, namely slim, oval, and round. Kewal Bulu Hideung Variety from Banten has a round shape with a ratio of 1.99 between its length and width, and Tunggul Hideung variety has a slim shape with a ratio of 3.10 between its length and width, while other varieties have an oval shape with a ratio between 2.00-3.00 between its length and width. According to [12], the size and shape of rice is the dominant character derived from the genetic characteristics of the parent and can be used as a parameter for determining the purity of a variety. The length and shape of rice are influenced by genetic factors, agroecosystems, and land fertility.

All rice varieties studied have a variety of sizes, shapes, and colors, as well as the appearance of grain and rice, as seen in Figure 1 and Figure 2. The grain color is generally yellow, but the yellow Kuriak Kusuik grain is mixed with brown. The variety of Kewal Bulu Hideung and Kewal Sampai Putih also have fur on their grain. The color of rice is not only white, but also yellowish as on the Kewal Gudril variety, red on the MS Pendek variety and pale white color on the Susu Putih glutinous rice variety.

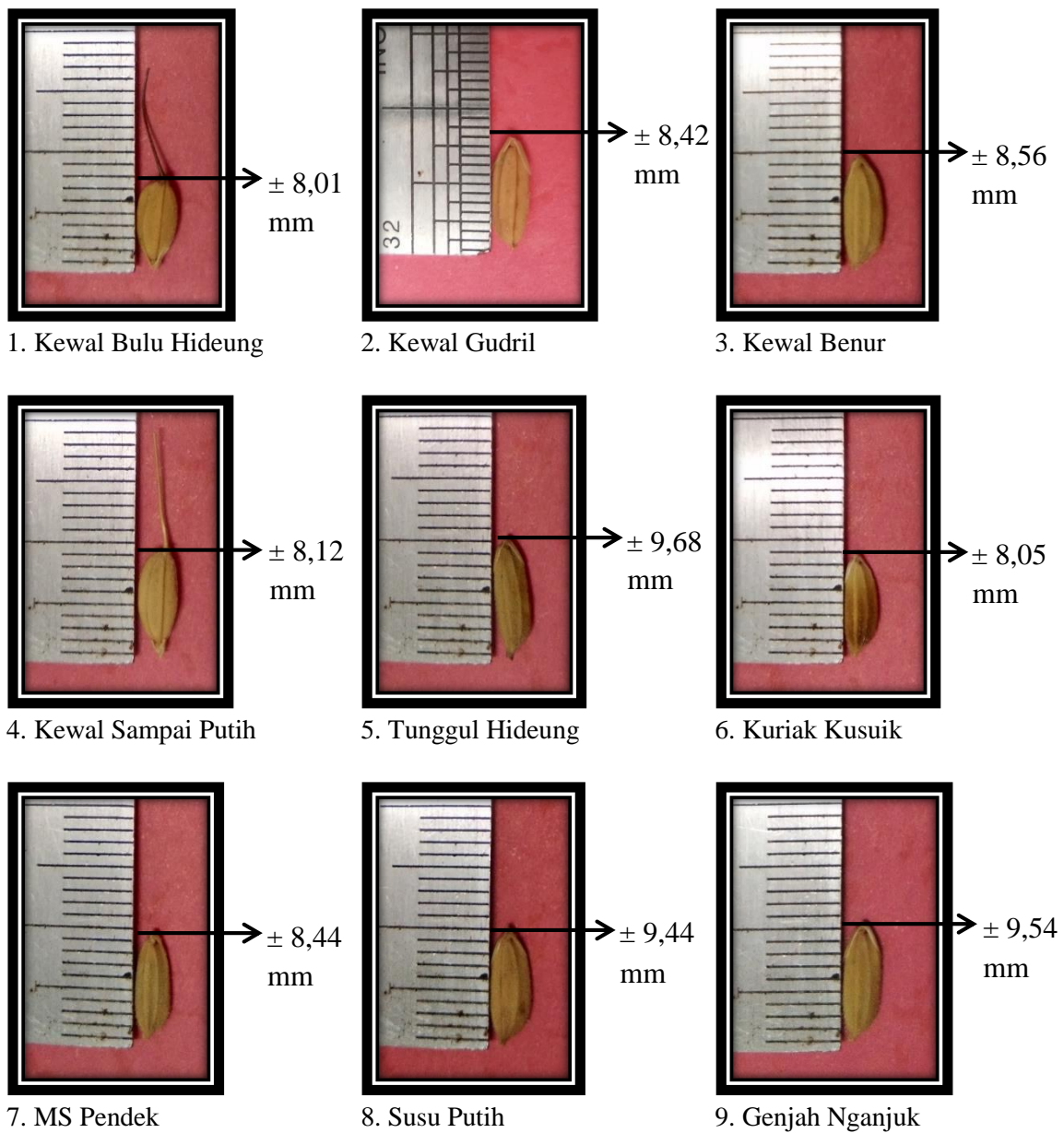
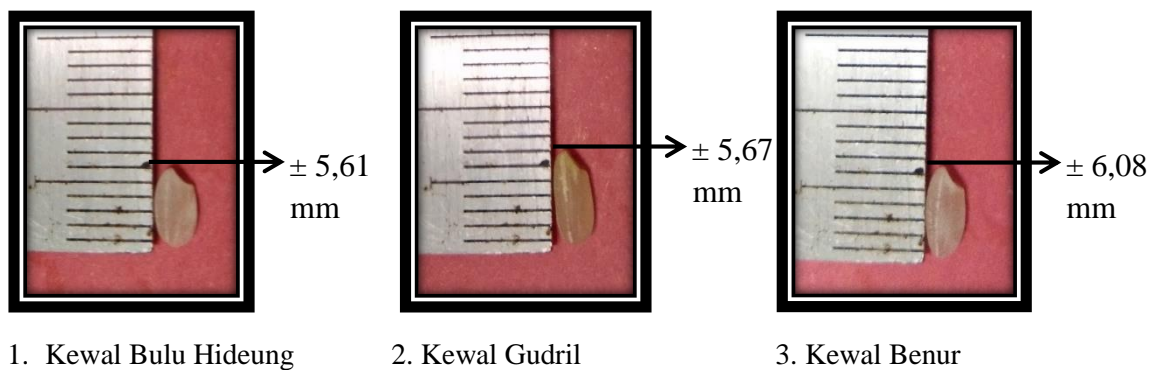


Figure 1. Diversity of shape, size and color of grain in 9 local Indonesian rice varieties



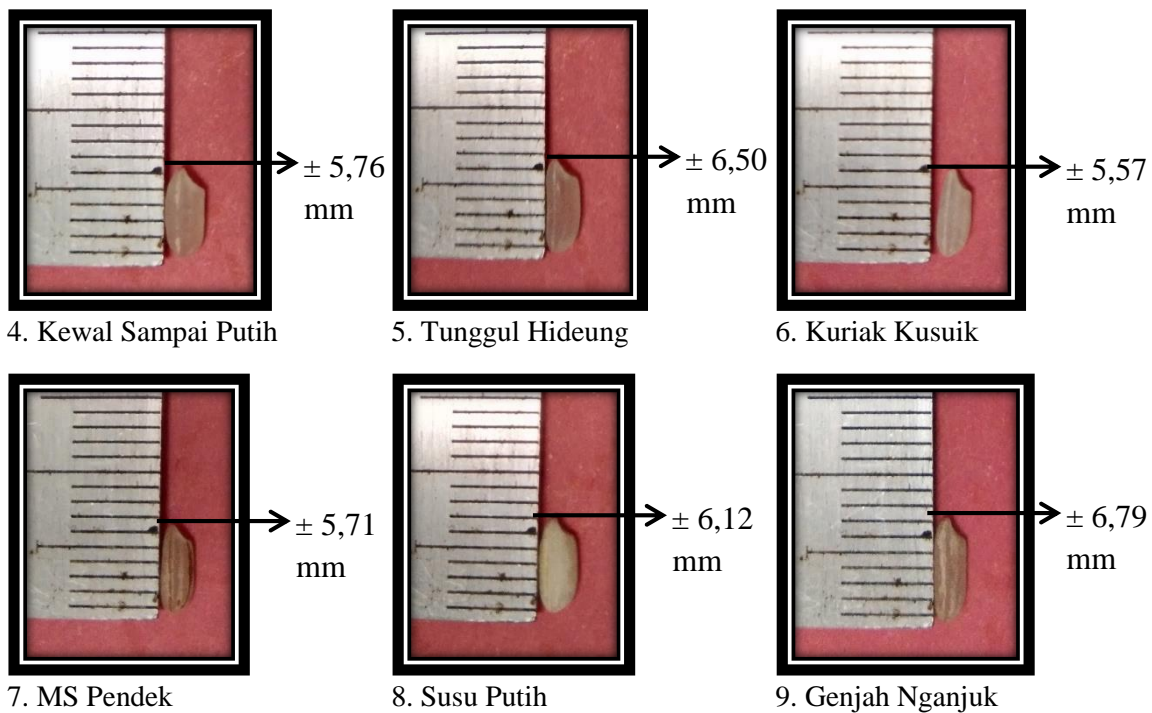


Figure 2. Diversity of shape, size and color of rice in 9 local Indonesian rice varieties

3.2. 1000 grain weight in grain and rice

The weight of 1000 points indicates the weight of each grain which determines the yield of production. 1000 grain weight grain also determines the yield of milled rice. This value can be used to determine whether there is a mixture in a rice sample on the market. It also can be used to determine the purity of a rice variety. The results of an analysis of the measurement of 1000 grain weights on the grain and rice studied are presented in Figure 3.

The weight value of one thousand grains analyzed ranged between 20.62 - 28.23 grams, while the weight value of one thousand grains of rice ranged between 14.09-22.44 grams. According to [13], one thousand grains are affected by the availability of nutrients in the soil during rice planting. Nutrient deficiencies at the time of planting will cause in the weight of a thousand grains produced lower than its optimum potency.

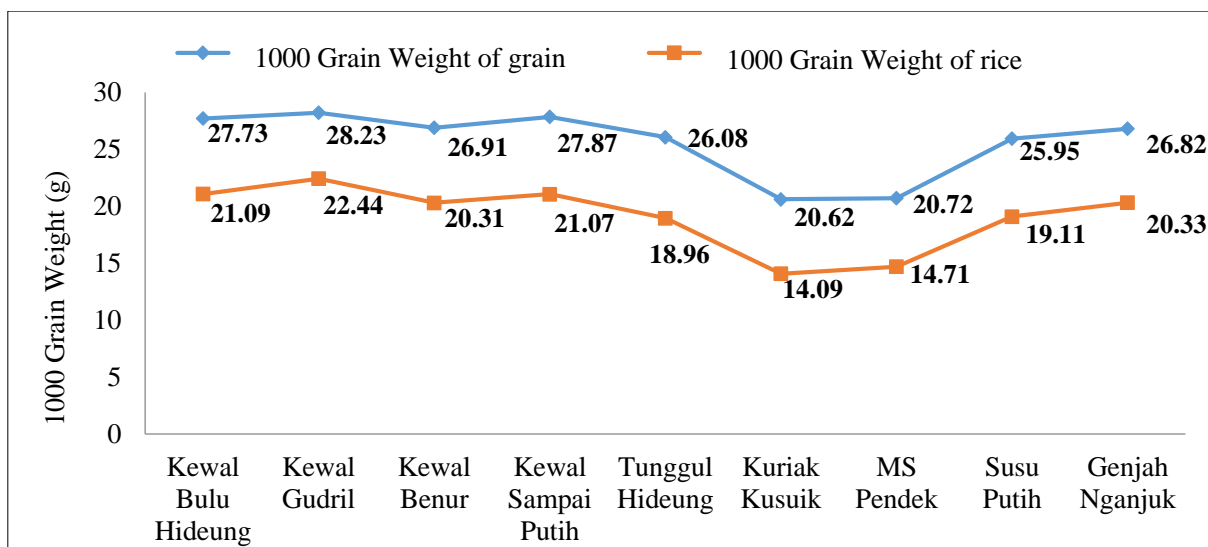


Figure 3. 1000 weight of grain and rice

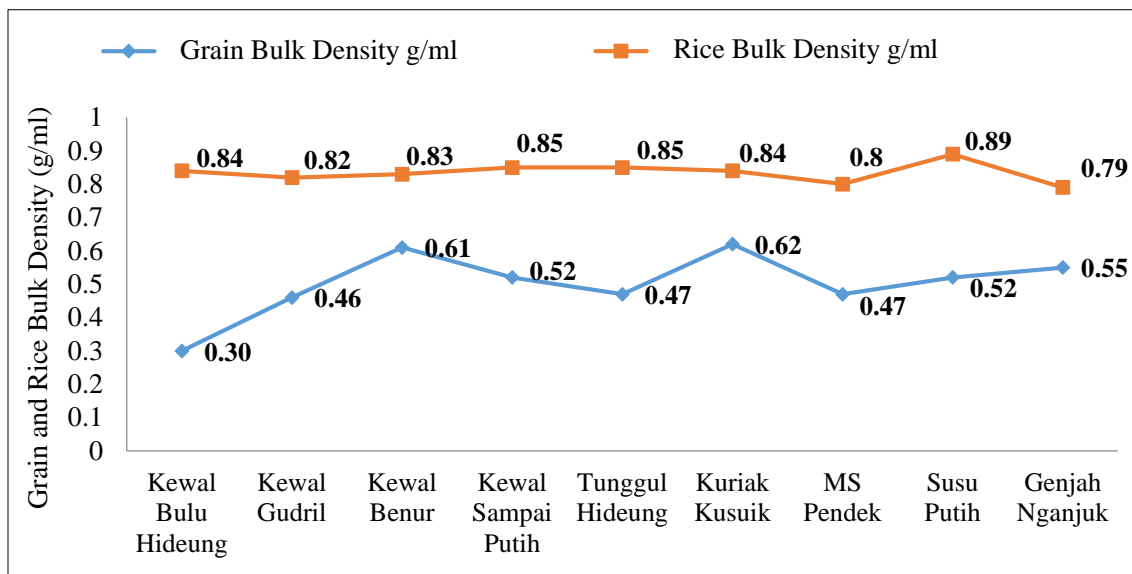


Figure 4. Grain and rice bulk density

Table 3. Percentage of chalkiness rice

Varieties	White-based Rice (%)	White-belly Rice (%)	White-core Rice (%)	Milky-white Rice (%)	Rice Total Whitewashing (%)*	Perfect Rice (%)
Kewal Bulu Hideung	1,4	44,4	5,2	1,0	52,0	48,0
Kewal Gudril	0,0	73,4	4,6	5,4	83,4	16,6
Kewal Benur	0,0	59,6	9,6	0,0	69,2	30,8
Kewal Sampai Putih	0,0	83,0	9,2	5,8	98,0	2,0
Tunggul Hideung	0,0	4,6	9,2	1,2	15,0	85,0
Kuriak Kusuik	0,6	1,4	32,2	1,8	36,0	64,0
MS Pendek	0,8	24,4	23,0	7,0	55,2	44,8
Susu Putih	-	-	-	-	-	-
Genjah Nganjuk	1,4	0,4	9,0	0,0	10,8	89,2

Note:

*Total Whitewashing Rice (%) = White-based Rice + White-belly Rice + White-core Rice + Milky-white Rice

Total observed rice (%) = total whitewashing rice+ Perfect Rice = 100%

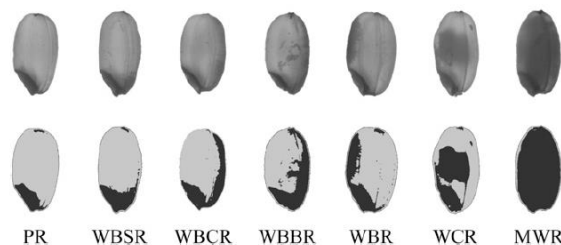


Figure 5. Grouping chalkiness: perfect rice (PR), white-based rice (WBSR), white-back rice (WBCR), white-back and -based rice (WBBR), white-belly rice (WBR), white-core rice (WCR) and milky-white rice (MWR) (Yoshioka, 2007).

3.3. Grain and rice bulk density

The density of grain or rice is a measure that describes the weight of grain or rice per unit volume expressed in units of g/ml. 1000 grain weight grain also determines the yield of milled rice. The size and shape of the grain and rice also directly affect the density. The rough rice of each variety show shows the least value of actual density, which agrees with [14], who stated that the specific gravity of paddy is lower than that of brown rice. Also, [15] reported similar results in the case of the actual density of rice by processing.

The bulk density of rice varieties in Indonesia ranges from 0,45 - 0.58 g/mL. Thus all grain samples are within the bulk density range, except for the Kewal Bulu Hideung grain variety which has a bulk density below the range of only 0.30 g/mL. The cause of this deference is the Kewal Bulu Hideung variety has fur at the tip of its grain, thereby reducing its density in storage. The Kuriak Kusuik has the highest bulk density of rice, and the lowest is possessed by the Kewal Bulu Hideung grain. It means that the Kewal Bulu Hideung grain needs two times more storage space than the Kuriak Kusuik grain, whereas the densest rice is possessed by Susu Putih variety. That is, for the same weight of Genjah Nganjuk rice requires 1.13 times more storage space than Susu Putih rice.

3.4. Percentage of number of chalking rice (chalkiness)

Whitewashing grains are white broken rice skin such as chalk and soft texture caused by physiological factors [16]. This white area is the result of very little starch development in the peripheral area of the endosperm. This is caused by insufficient carbohydrate transport during rice ripening [17].

When referring to the SNI standard for rice (2015) which requires a maximum content of limestone grains of 5%, then the level of whitewashing rice in varieties of Kewal Gudril (5,4 %), Kewal Sampai Putih (5.8%) and MS Pendek (7.0%) does not meet these requirements. Whereas the Susu Putih variety is glutinous rice so it cannot be observed its whitewashing grain because the color of the rice is indeed all murky white like glutinous rice in general. *Chalkiness* grouping based on Figure 5. below.

4. Conclusions

The grain size indicates that all grain is very long. The grain form of the Tunggul Hideung and Genjah Nganjuk varieties is slim, and the other varieties are oval-shaped. Whereas in the size of rice, the Genjah Nganjuk variety is long and the other varieties are medium. Rice forms of Kewal Bulu Hideung are round, Tunggul Hideung is slim and other varieties are oval-shaped.

The weight value of one thousand grains analyzed ranged between 20.62 - 28.23 grams, while the weight value of one thousand grains of rice ranged from 14.09 - 22.44 grams. The grain samples studied have densities in the range of 0.3 - 0.55 g / mL. Kewal Bulu Hideung variety has the smallest density (0.3 g / ml) because there are long black feathers in each grain of grain. The level of whitewashing rice in the studied rice fulfills SNI requirements (maximum 5%), except varieties of Kewal Gudril (5.4%), Kewal Sampai Putih (5.8%) and MS Pendek (7.0%).

Rice varieties on the market are very diverse. Therefore, the physical characteristics of them need to be known by consumers in order to obtain consumers preferences. As a result, we can find out the characteristics of rice they preferred and can arrange appropriate steps to gain those rice.

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