

# Physical and Milling Quality of Milled Rice in Indonesia

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## Abstract

More than 250 rice varieties are grown in Indonesia from new superior varieties and local varieties with aromatic, non-aromatic aromas and pigmented rice. Rice quality is one factor that must be considered in addition to high productivity. Generally, the quality of grain and rice quality in Indonesia have met the quality standards set based on SNI 0224-1987/SPI-TAN/01/01/1993 and SNI 6128:2020. Rice quality is determined by several factors such as grain appearance, nutritional value, cooking and eating quality and become one of the foremost considerations for rice buyers. Such information can be utilized as basic data of character of genetic resources on assembling of new superior varieties by rice breeders. Those information can be used as a descriptive information for farmers and rice productivity, high yield, and better rice quality. Good quality local cultivar can be used as parents for the formation of new superior varieties.

**Keywords:** physical quality, milling quality, milled rice, Indonesia.

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## Introduction

The most important food crop in Indonesia is rice (*Oryza sativa* L.), since rice is the main staple food for most Indonesian people. The level of rice consumption is still quite high, reaching 111.58 kg per capita per year (CBS, 2018). Therefore, rice in Indonesia is an important and strategic commodity with increasing demand, along with a population growth rate which for 2010-2020 was 1,25% (CBS, 2021). There are around 300 rice varieties grown in Indonesia from new superior varieties and local varieties with aromatic, non-aromatic aromas and pigmented rice.

Local rice varieties are rice varieties that have long been adapted in certain areas. Therefore, those local varieties have location-specific characteristics in every particular area. Each variety, as well as local variety, has its own superiority and inferiority.

New superior variety rice is a rice variety that can be planted repeatedly with good treatment. New superior varieties are one component of the rice cultivation technology package that can significantly increase farmers' productivity and income. The new superior varieties of rice released in 2008 no longer uses the river name, but uses a new nomenclature, namely: using the names *Inpa* for Rice Inbreds and *Hipa* for Rice Hybrids. Hybrid rice is a single-planted rice variety where the yield will be maximized once planted. However, if the seeds are planted again then the yield will be reduced considerably. As for the naming of Paddy Inbreds (*Inpa*) for various agroecosystems, add a syllable at the end of the word

*Inpa*, as follows: *Inpari* for Inbred Rice for Irrigated Rice Fields; *Inpara* for Swamp Rice Inbreds (low tide/tidal); and *Inpago* for Gogo Rice Inbreds. New superior varieties rice can be non-aromatic, aromatic and/or pigmented rice (Sasmita et al., 2020).

Aromatic Rice is an aromatic rice plant that naturally has a fragrant aroma like pandan or popcorn. This pandanus scent is easily recognized from the aroma of rice, even in rice plant during its flowering phase, due to substance known as 2-Acetyl-1-pyrroline (2-AP) (Ahmed et al, 1996 and Tanchotikul and Hsieh 1991). To produce aromatic rice with higher 2-AP levels, it is recommended that aromatic rice plants be planted in cool climatic conditions, and then be harvested earlier than ordinary varieties. Pigmented rice or colored rice is distinguished by the rice grain having red brown or dark purple color in its covering layers. Pigments, which are located in the aleurone layer of rice grain, have been reported as a mixture of anthocyanin compounds, which belong to the family of flavonoids (Yawadio et al., 2007).

Rice is mainly consumed in whole milled form. Rice quality is one factor that must be considered in addition to high productivity. Rice quality is determined by several factors such as grain appearance, nutritional value, cooking and eating quality (Verma et al, 2015) and become one of the foremost considerations for rice buyers (Bao, 2012). Rice quality is of great importance for all people involved in producing, processing and consuming rice, because it affects the nutritional and commercial value of grains.

Nowadays consumers are looking for rice with higher amounts of nutrients, shorter cooking time, high volume expansion ratio, slender in shape, and “medium to soft” texture with a natural “popcorn” aroma after cooking (Demont et al., 2012). Consumer preference and willingness to pay for rice depends on the appearance, organoleptic quality (Akoa-Etoa et al., 2016; Demont et al., 2012), and presumed nutritional quality. Generally, rice without impurities, translucent, with a high percentage of head rice is preferred (Akoa-Etoa et al., 2016; Demont, 2013; and Diako et al., 2010). Rice quality depends on the variety, preharvest and postharvest production, and processing methods (Yanjie et al., 2018).

The physical quality of milled rice is determined by the length and shape of the rice, the absence of chalky grains, and translucence (Sreethong, et al., 2018). Information on the physical and milling quality of rice is very much needed and is still limited. Moreover, it can be utilized as basic data on character of genetic resources in assembling of new superior varieties by rice breeders. Those information can be used as a descriptive information for farmers and rice producers who prefer the type of rice that has high productivity, high yield, and better rice quality. The rice milling quality is also one of the factors that consumers consider in buying rice. Milled rice quality is also one of the determinants of rice prices. Therefore, this paper aims to review the physical and milling quality of local cultivar, new superior varieties, aromatic rice and red pigmented rice in Indonesia.

## Methods

This research method is a literature study of various scientific papers related to rice quality and other aspects. Primary data information is reviewed and re-analyzed into table groups according to the required parameters.

## Grain Quality Standard

**Table 1.** Grain quality qualitative requirements (SNI 0224-1987/SPI-TAN/01/01/1993)

No	Quality Component	Quality		
		I	II	III
1	Moisture content (% maximum)	14.0	14.0	14.0
2	Empty grain (% maximum)	1.0	2.0	3.0
3	Damaged + yellow grains (maximum)	2.0	5.0	7.0
4	Chalky + green grain (% maximum)	1.0	5.0	10.0
5	Red grain (% maximum)	1.0	2.0	4.0
6	Foreign matter (% maximum)	-	0.5	1.0
7	Others varieties grain (% maximum)	2.0	5.0	10.0

Source: NSA, 1993

Grain is the part of rice plants that have been separated from the stalks by threshing. Good quality rice comes from good quality grain as well. Some parameters of grain quality include moisture content, empty grain, damaged grains + yellow grains, chalky + green grain, red grains, foreign matter, and other paddy varieties. Based on paddy quality standards (SNI 01-0224-1987/SPI-TAN/01/01/1993), paddy is divided into 3 quality classes (NSA, 1993) (Table 1).

## Physical grain quality

Grain moisture content of all types of rice such as local rice, new superior varieties rice, aromatic rice and pigmented rice have met the requirements of Indonesian National Standard of grain (SNI 0224-1987/SPI-TAN/01/01/1993) (NSA, 1993) which is below 14% (Table 2). The variation in grain moisture content is caused by differences in harvest time conditions and drying process. Proper grain moisture content is required at the time of the milling process to obtain a high percentage of head rice. High grain moisture content causes the rice to break easily, while too low moisture content will increase the breakage of the milled rice produced (Suganthi & Nacchair, 2015). According to Belitz *et al.*, (2009), reducing moisture content in a food can slow the occurrence of various chemical reactions and prevent the growth of microorganisms so that the shelf life of the food is longer.

The percentage of empty grain of all types of rice such as local rice, new superior varieties rice, aromatic rice and pigmented rice has met the requirements for the 3 quality class of SNI grain (SNI 0224-1987/SPI-TAN/01/01/1993) (NSA, 1993), namely below 3%, except for new high yielding varieties (Hipa 8) of 7.36% (Table 2). Empty grain are grains which are not fully developed, but the husks are intact and do not contain rice grains. This includes grain where both husks are intact, but there are no grains of rice due to pest attack or other reasons.

Chalky grains are broken rice husks (after peeling) which are white in colour and the whole grain of rice is brittle like chalk (chalky) due to physiological factors. Unhulled rice are rice grains that have not yet fully ripened, whose contents are still fragile and calcified. The percentage of green grains and chalky grains of all types of rice such as local rice, new superior varieties rice, aromatic rice and pigmented rice have met the requirements for quality of the second class of SNI grain (SNI 0224-1987/SPI-TAN/01/01/1993) (NSA, 1993) which is below 5%, except for local rice from DI Yogyakarta (Menur) which is 6.10% (Table 2).

The percentage of yellow + damaged grains of all types of rice such as local rice, new superior varieties rice, aromatic rice and color rice has met the requirements for quality the third class of SNI grain (SNI 0224-1987/SPI-TAN/01/01/1993) (NSA, 1993) which is below 7%, except for local rice from DI

Yogyakarta (Jasmine, Mentik Putih, Srikuning and Mentik Susu) ranging from 7.72-27.82% and new high yielding varieties (Inpara 3) by 8.25% (Table 2).

Damaged grain is rice that breaks the skin after the grain is peeled and becomes damaged due to mechanical, physiological and biological factors.

**Table 2.** The range of physical quality of paddy parameters of several paddy type in Indonesia.

Paddy type	Variety	Moisture content (%)	Empty grain (%)	Green+ chalky grain (%)	Yellow+ damaged grain (%)	Reference
Local Rice Cultivar	Menur, Jasmine, Mentik Putih, Srikuning, Mentik Susu, Kenanga	10.45-12.70	0.41-2.82	2.21-6.10	2.34-27.82	Indrasari et al., (2017a)
New Superior Varieties	Ciherang, Inpari 1, Inpari 6, Inpara 3, Inpara 4, Hipa 8	10.7-12.6	0.91-7.36	0.30-2.01	0.41-8.25	Indrasari et al., (2017b)
Aromatic Rice	Batang Gadis, Gilirang, Situ Patenggang, Sintanur	12.9-13.6	1.3-3.7	0.1-1.9	1.2-6.7	Indrasari et al., (2018)
Pigmented Rice	Segreng, Mendel, Aek Sibundong	10.00-13.45	1.82-1.87	0.14-0.36	0.06-2.34	Fajri et al., 2017

In Table 3 it can be seen that the grain density of local rice ranges from 491-592 g/l, while those of new superior varieties rice 476-552 g/l, aromatic rice between 549-553 g/l, and pigmented rice between 535.5-553 g/l. The weight of 1000 grains of local rice ranged from 21.62-25.52 g, while those of new superior varieties rice 19.41-30.63 g, aromatic rice between 23.7-28.3 g and color rice 26.18-27.80 g. The measurement of grain density aims to estimate the yield of milled rice. According to Rather et al. (2016), density values are useful in sizing grain hoppers and storage facilities. Density values could be used to calculate the rate and mass transfer during aeration and drying (Malik & Saini, 2016). According to Varnamkhasti *et al.*, (2008), information about grain density is needed in designing silos and grain storage containers. The difference in grain density parameters and 1000 grain weight can be caused by differences in environmental conditions during the process of grain filling and varieties. The high grain density and weight of 1000 grains will also produce high yields of milled rice. The measurement of grain density aims to estimate the yield of milled rice. Thompson & Mutters, (2006) reported that the weight of 1000 grains is an inherited characteristic.

**Table 3.** The range of physical quality of paddy parameters of several type of paddy in Indonesia.

Paddy type	Variety	Density (g/l)	1000 grain weight (g)	References
Local Rice Cultivar	Menur, Jasmine, Mentik Putih, Srikuning, Mentik Susu, Kenanga	491-592	21.62-25.52	Indrasari et al., (2017a)
New Superior Varieties	Ciherang, Inpari 1, Inpari 6, Inpara 3, Inpara 4, Hipa 8	476-552	19.41-30.63	Indrasari et al., (2017b)
Aromatic Rice	Batang Gadis, Gilirang, Situ Patenggang, Sintanur	549-553	23.7-28.3	Indrasari et al., (2018)
Red Pigmented Rice	Segreng, Mendel, Aek Sibundong	535.5-553	26.18-27.80	Fajri et al, 2017

### Physical Quality of Milled Rice

The physical qualities of milled rice which consist of length, width, shape/size, whiteness degree, transparency, and milling degree are presented in Table 3 and Table 4. Juliano (1994) classifies the length of rice as follows: very long (> 7.5 mm), long (6.61-7.5 mm), medium (5.51-6.60 mm), and short (<5.50 mm). Table 4 shows that the length of local rice ranges from 5.66-7.30 mm, including medium to long category, the length range of new superior varieties rice ranges from 5.70-7.60 mm, including medium to very long category, aromatic rice length ranges between 6.04-6.40 mm, including medium and long category; and the range of pigmented rice is between 6.64-7.00 mm, including long category.

The ratio of length and width of the rice determines the classification of the grain shape. Juliano (1994) classifies rice into 4 types: slender (> 3.0), medium (2.1-3.0), bold (1.1-2.0), and round ( $\leq 1$ ). Based on the classification, the shape of local rice and new superior varieties rice ranged from 2.20-3.21 and 2.50-3.60, respectively, i.e. medium to slender. Meanwhile, aromatic rice and pigmented rice ranged from 2.25-2.67 and 2.72-3.04, respectively, which were of medium category (Table 4).

In general, consumers prefer rice with long grain and slender shape. Shape, size, weight and seed uniformity are important factors in the rice industry. In addition, information on the ratio of length and width is required in determining the drying and processing equipment.

**Table 4.** The range of physical quality of rice parameters of several type of paddy in Indonesia.

Paddy type	Variety	Length (mm)	Width (mm)	L/W (Shape)	Reference
Local Rice Cultivar	Menur, Jasmine, MentikPutih, Srikuning, Mentik Susu, Kenanga	5.66-7.30	2.27-2.70	2.20-3.21	Indrasari et al., (2017a)
New Superior Varieties	Ciherang, Inpari 1, Inpari 6, Inpara 3, Inpara 4, Hipa 8	5.70-7.60	2.10-2.30	2.50-3.60	Indrasari et al., (2017b)
Aromatic Rice	Batang Gadis, Gilirang, Situ Patenggang, Sintanur	6.04-6.40	2.34-2.68	2.25-2.67	Indrasari et al., (2018)
Red Pigmented Rice	Segreng, Mendel, AekSibundong	6.64-7.00	2.29-2.49	2.72-3.04	Fajri et al., (2017)

Another physical characteristic of milled rice that plays a role in determining the level of acceptance is the color of rice. Rice color criteria are measured in relative manner, compared with the white crystal color of BaSO<sub>4</sub> which has a whiteness degree of 87%. The range of whiteness degree of local variety, new superior variety and aromatic rice is 41.0 (Inpari 1) to 57.90 (Menur) (Table 5). The range of whiteness degrees of local five glutinous rice from Indonesia ranged from 25.35 (Ketan Gadok) to 67.45 (Ketan Nangka) (Indrasari et al., 2009). Another study on local rice cultivar shows that, the whiteness degree of Kewal Balik Semah (55.8%) was higher than that of Cere Mas (43.6%) and Segara Anak (50.1%), while the transparency of Kewal Balik Semah (1.2%) was lower than that of Segara Anak (2.8%), but was higher than that of Cere Mas (0.5%) (Purwaningsih & Indrasari, 2019). The whiteness degree does not always affect the level of rice transparency.

In addition to the color of rice, the physical characteristics of rice that directly affect the level of consumer preferences for milled rice is the transparency of rice grains. Consumers prefer white and transparent milled rice. The rice transparency is

determined by the genetic traits and the milling method. The use of friction method which involves friction between rice grains will produce rice with a higher value of transparency than of abrasive method which involves friction with grinding stone. The range of whiteness degree of local variety, new superior variety and aromatic rice is 1.42 (Mentiksusu) to 3.50 (Menur) (Table 5). On the other than the range of translucency of local five glutinous rice from Indonesia is between 0.24 (Ketan Gadok) to 0.85 (Ketan Bilatung) (Indrasari et al., 2019)

The milling degree is a joint criterion between the whiteness degree and the transparency of rice grain. Increased levels of rice husking will produce in milled rice with higher degree of milling. Measurement of milling degree is carried out using Satake Milling Meter. As a comparison, white crystals of BaSO<sub>4</sub> were used with a dosage value of 199. The range of milling degree of local variety, new superior variety and aromatic rice is 101 (Inpari 1) to 181 (Menur) (Table 5). Measurement of the milling degree of local glutinous rice in Indonesia using Satake Milling Meter shows the range of 51.5 (Ketan Pecut) to 199 (Ketan Nangka) (Indrasari et al., 2019).

**Table 5.** The range of physical quality of rice parameters of several type of paddy in Indonesia.

Paddy type	Variety	Whiteness Degree (%)	Translucency (%)	Milling Degree *)	Reference
Local Rice Cultivar	Menur, Jasmine, Mentik Putih, Srikuning, Mentik Susu, Kenanga	42.10-57.90	1.42-3.50	107.0-181.0	Indrasari et al., (2017a)
New Superior Varieties	Ciherang, Inpari 1, Inpari 6, Inpara 3, Inpara 4, Hipa 8	41.0-47.90	1.90-3.10	101-130	Indrasari et al., (2017b)
Aromatic Rice	Batang Gadis, Gilirang, Situ Patenggang, Sintanur	44.6-49.5	1.70-2.70	111-163	Indrasari et al., (2018)

\*) Scale of Satake Milling Meter

### Rice Quality Standard

To determine the quality of rice circulating in the market, ensure food safety, and achieve healthy market competition, the government sets the Indonesian national standard for rice, namely SNI

6128:2020 (Table 6) (NSA, 2020). This standard is a revision of SNI 6128:2015, based on suggestions from all stakeholders by taking into account the condition of rice quality in the market and rice quality standards used by other rice producing countries.

**Table 6.** Quality requirements for non-organic and organic rice.

No	Quality component	Unit	Premium	Medium1	Medium 2
1	Head rice (minimal)	%	85.00	80.00	75.00
2	Broken rice (maximal)	%	14.50	18.00	22.00
3	Groats (maximal)	%	0.50	2.00	3.00
4	Red <sup>a</sup> /White <sup>b</sup> /Black <sup>c</sup> grain (max )	%	0.50	2.00	3.00
5	Damaged grain (maximal)	%	0.50	2.00	3.00
6	Chalky grain (maximal)	%	0.50	2.00	3.00
7	Foreign matter (maximal)	%	0.01	0.02	0.03
8	Paddy grain (maximal)	(grain/100 g)	1.00	2.00	3.00

<sup>a</sup>)for white rice or glutinous rice (black glutinous rice and white glutinous rice)

<sup>b</sup>)for red rice and black rice

<sup>c</sup>)for red rice

Source: NSA, 2020.

### Milling Quality of Milled Rice

The moisture content of milled rice local cultivar, new superior varieties, and pigmented rice are under 14% which fulfilled the general requirement standards quality of milled rice based on INS No.6128-2020. The range of yield of brown rice of local cultivar is between 72.63% (Mentik Putih) – and 76.62% (Menur), while those of new superior varieties is between 75.70 % (Inpara 3) - and 79.80% (Ciherang), while red pigmented rice is between 77.3% (Segreng) – and 79.9% (Aek Sibundong). The range of yield of milled rice of local cultivaris between 62.57% (Mentik Putih) - and 66.67% (Kenanga), while that of new superior varieties is between 64.70% (Inpara 4)- and 72.00% (Inpari 1), and red pigmented rice is between 70.1% (Segreng) – and 70.9% (Mandel) (Table 6). Another study of local cultivar shows that, the yield of Kewal Balik Semah milled rice is 62.5% lower than that of

Cere Mas (65.7%) and Segara Anak (71.5%) (Purwaningsih & Indrasari, 2019).

Head rice is a component of physical quality of rice that directly affects the level of acceptance by consumers. Consumers do not like milled rice with low head rice percentage. Standards of quality of milled rice based on INS No. 6128-2020 for medium 2 class quality requires a minimum of 75% of head rice, while for medium 1 class requires a minimum of 80%, and for premium class requires a minimum of 85% (Table 6). When compared with the requirements of the INS, the range of head rice percentage of local cultivar is between 74.92% (Menur) – and 91.67% (Mentik Putih), those of new superior varieties is between 61.30% (Ciherang) - and 97.60% (Inpari 1), while those of aromatic rice is between 52.40% (Situ Patenggang) - and 92.20% (Sintanur), while those of red pigmented rice is between 86.0% (Aek Sibundong) –and 86.9 % (Segreng) (Table 6). Local cultivar, red pigmented rice,

some of the new superior varieties and aromatic varieties fulfilled the minimum requirement of medium 2 class of the standard. Local rice with a high percentage of head rice (Mentik Putih) can be used as one of the parents for the formation of new superior varieties.

In contrast with head rice, high percentage of broken rice cause declining of consumer acceptance. For domestic food procurement (INS No. 6128-2020), according to the quality standards of milled rice (second medium grade), the maximum percentage of broken rice is 22%. Ciherang (38.4%), a new superior

variety; and Situ Patenggang (46.6%), an aromatic variety have the highest percentage of broken rice (Table 7). One of the factors that determine the high percentage of broken rice in milled rice is moisture content. When grain was milled with low moisture content, it will cause high broken grain. Conversely, if the grain is too wet, it will produce a high grain groats. The groats of local rice cultivar, new superior varieties, aromatic rice and red pigmented rice fulfilled to be categorized the medium 2 class standard of rice (Table 7).

**Table 7.** The range of milling quality of rice parameters of several type of paddy in Indonesia.

Paddy type	Variety	Moisture Content (%)	Yield of Brown Rice (BR) (%)	Yield of Milled Rice (MR) (%)	Head Rice (%)	Reference
Local Rice Cultivar	Menur, Jasmine, Mentik Putih, Srikuning, Mentik Susu, Kenanga	10.35-12.80	72.63-76.62	62.57-66.67	74.92-91.67	Indrasari et al., (2017a)
New Superior Varieties	Ciherang, Inpari 1, Inpari 6, Inpara 3, Inpara 4, Hipa 8	11.1-12.3	75.70-79.80	64.70-72.00	61.30-97.60	Indrasari et al., (2017b)
Aromatic Rice	Batang Gadis, Gilirang, Situ Patenggang, Sintanur	-	-	67.90-69.90	52.40-92.20	Indrasari et al., (2018)
Red Pigmented Rice	Segreng, Mendel, Aek Sibundong	11.1-12.4	77.3-79.9	70.1-70.9	86.0-86.9	Fajri et al., 2017

**Table 8.** The range of milling quality of rice parameters of several type of paddy in Indonesia.

Paddy type	Variety	Broken Grain (%)	Groats (%)	Green+Chalky Grain (%)	Yellow+Damaged Grain (%)	Reference
Local Rice Cultivar	Menur, Jasmine, Mentik Putih, Srikuning, Mentik Susu, Kenanga	7.37-23.95	0.26-1.37	0.01-0.79	0.09-6.17	Indrasari et al., (2017a)
New Superior Varieties	Ciherang, Inpari 1, Inpari 6, Inpara 3, Inpara 4, Hipa 8	2.60-38.40	0.10-0.90	0.10-2.10	0.10-1.60	Indrasari et al., (2017b)
Aromatic Rice	Batang Gadis, Gilirang, Situ Patenggang, Sintanur	7.50-46.60	0.20-0.90	0.01-1.16	0.32-1.25	Indrasari et al., (2018)
Red Pigmented Rice	Segreng, Mendel, Aek Sibundong	12.94-13.61	0.11-0.34	0.02-0.36	0.06-1.20	Fajri et al., 2017

Green+chalky grains and yellow+damaged grains are the components consumers consider in choosing the rice they buy. In general, consumers do not like milled rice with green+chalky grain content and high

yellow+damaged grains. In relation to this, INS No 6128:2020 requires green+chalky grain content and yellow+damaged grains to be maximum of 3% each for second class medium grade. Compared with these

requirements, the green+chalky grains of local cultivar, new superior varieties, aromatic rice, and red pigmented rice fulfilled this requirement, except Srikuning (local variety) for yellow+damaged grains (6.17%).

## Conclusions

As an agricultural country, Indonesia has abundant paddy varieties with has various types of rice varieties and various variations in the grain and rice quality. Types of rice varieties include inbred rice and hybrid rice which could have aromatic/non-aromatic characters as well as white or pigmented rice. Generally, the quality of grain and rice quality has met the quality standards set based on SNI 0224-1987/SPI-TAN/01/01/1993 and SNI 6128:2020. Rice quality is determined by several factors such as grain appearance, nutritional value, cooking and eating quality and become one of the foremost considerations for rice buyers. Such information can be utilized as basic data of character of genetic resources for assembling new superior varieties by rice breeders. Those information can be used as a descriptive information for farmers and rice producers who prefer the type of rice that has high productivity, high yield, and better rice quality. Good quality local cultivar can be used as parents for the formation of new superior varieties, for example Mentik putih cultivar.

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