



## Research Article

# Milling Recovery of BRR1 dhan71 and BRR1 dhan82 under Different Moisture Content

Md. Golam Kibria Bhuiyan<sup>1\*</sup>, Md. Moudud Ahmmed<sup>2</sup>, Subrata Paul<sup>1</sup>, Md. Durrul Huda<sup>1</sup>, Mohammad Afzal Hossain<sup>2</sup>, Anisur Rahman<sup>3</sup> and Bidhan Nath<sup>1</sup>

<sup>1</sup>Farm Machinery and Postharvest Technology Division, Bangladesh Rice Research Institute, Gazipur.

<sup>2</sup>Workshop Machinery and Maintenance Division, Bangladesh Rice Research Institute, Gazipur.

<sup>3</sup>Department of Farm Power and Machinery, Bangladesh Agricultural University, Mymensingh.

## Article Information

Received : 12 December 2024

Revised : 24 December 2024

Published : 31 December 2024

## ABSTRACT

Moisture content significantly impacts rice milling quality, influencing head rice yield and consumer acceptance. This study investigated the effect of moisture content on the milling recovery of two parboiled rice varieties, BRR1 dhan82, and BRR1 dhan71, using an air-blow type Engelberg huller. Both varieties achieved the highest head rice recovery (around 62%) at a moisture content of 10.2-11.3% (wet basis). Lower moisture content resulted in increased broken rice percentage. No un-hulled paddy was found in the milled product. These findings suggest that 10-11% moisture content is optimal for milling parboiled rice with this huller, maximizing head rice yield while minimizing breakage. This information provides valuable insights for optimizing parboiled rice production and improving efficiency in the rice industry, potentially leading to significant cost savings and increased profitability for rice producers.

**Keywords:** rice, milling yield, head rice, broken rice, capacity, moisture content

**Correspondence:** Md. Golam Kibria Bhuiyan ✉: [kibria\\_1971@yahoo.com](mailto:kibria_1971@yahoo.com)

**Copyright:** Authors and Journal of Agricultural Machinery and Bioresources Engineering (JAMBE). This is an Open Access article distributed under the terms of the Creative Commons Attribution Non-Commercial License (<http://creativecommons.org/licenses/bync/4.0/>), which permits unrestricted non-commercial use, distribution and reproduction in any medium, provided the original work is properly cited.

## 1. Introduction

Rice, a staple food for a significant portion of the world's population, is essential to global food security [1]. The efficiency of rice milling, a pivotal stage in rice processing, dramatically influences the quality and quantity of rice grains obtained [2]. In agricultural research, the quest for high-yielding rice varieties with enhanced milling recovery has been ongoing to meet the increasing demand for quality rice [3]. This activity involves understanding the intricate relationship between rice cultivars, moisture content, and milling recovery. Milling, a vital processing step of rough rice (paddy), is usually done to produce white and polished grain. A commercial rice milling system is a multi-stage process where the paddy is first subjected to de-husking and then to remove the brownish outer layer, known as whitening [4]. One of the significant problems in the rice industry is the breakage of kernels during milling. As the cooking quality of broken rice could be better, the market value of broken grain is much less than that of whole grains [5]. The rice industry aims to achieve maximum head rice yield (HRY) from milling. HRY is the current standard for assessing commercial rice milling quality [6]. Several factors influence the breakage of rice in the milling process. Besides rice variety, management of post-harvest operations and especially drying conditions also affect the extent of kernel damage. Kernel breakage is closely related to fissure development in different stages of harvesting and post-harvesting operations [7, 8]. Among the factors affecting the broken kernels during the milling process, the final moisture content of paddy is one of the critical parameters that influence the quantitative and qualitative aspects of milling [9].

## Cite This Article

Bhuiyan, M. G. K., Ahmmed, M. M., Paul, S., Huda, M. D., Hossain, M. A., Rahman, A., and Nath, B. 2024. Milling recovery of BRR1 dhan71 and BRR1 dhan82 under different moisture content. *Journal of Agricultural Machinery and Bioresources Engineering*, 8(2):62-67. <https://doi.org/10.61361/jambe.v8i2.128>

Bangladesh Rice Research Institute (BRRI) has been at the forefront of developing high-yielding rice varieties tailored to Bangladesh's diverse agroecological conditions [10]. Among these varieties, BRRI dhan82 and BRRI dhan71 have garnered significant attention due to their promising characteristics and performance in the field [11]. However, their milling recovery under different moisture content remains a subject of investigation. Milling recovery refers to the percentage of whole rice grains obtained after the milling process relative to the initial unprocessed rice grains [12]. It is a critical parameter that directly impacts the economic viability of rice production and the quality of rice for consumers. Understanding the factors influencing milling recovery, such as rice cultivar and moisture content, is essential for optimizing rice processing techniques and ensuring maximum yield. Variations in the moisture content of rice grains significantly impact milling efficiency, as noted by [11]. This variation can dramatically influence the physical characteristics of rice grains, such as hardness, elasticity, and, ultimately, milling yield. Rice grains with high moisture content are softer and more prone to breakage during milling, reducing milling recovery [13]. Conversely, dehydrated grains may increase milling energy consumption and decrease head rice recovery. Thus, maintaining optimal moisture content is crucial for achieving high milling recovery rates.

BRRI dhan82 and BRRI dhan71 are recognized as top-performing rice types developed through BRRI's hard work in breeding. BRRI dhan82 stands out for its ability to produce lots of rice, top-notch grain quality, and adaptability to different environments. Likewise, BRRI dhan71 is known for consistently delivering good yields, being disease-resistant, and having high-quality grains [14]. Ali and Pandya (15) described parboiling as a hydrothermal procedure that gelatinizes the starch and rice inside grains. This method entails soaking rice in hot or cold water, steaming it with hot vapour, and then drying it under various circumstances. Despite impressive traits, it's yet to learn how these rice types behave when the moisture levels differ during milling. Exploring this aspect could give us valuable insights into how to process better-quality rice [6]. Therefore, the study's primary goal was to determine the best moisture levels for getting the most rice and the best-quality rice from BRRI dhan82 and BRRI dhan71.

## 2. Materials and Methods

### 2.1 Paddy sample conditions

The paddy used in this experiment was soaked in a drum for 36 hours. To generate high-quality rice, clean water was substituted for interval-soaked water every ten hours. Following a 36-hour, the water was extracted from the tank and placed in a small container with a local burner to steam. The BRRI drying floor served as the drying area. Drying took place on days with good solar exposure while preserving a 2-4 cm layer of grain thickness. The paddy was still being steered every 30 min. The Paddy sample was dried to the required moisture level and then heaped at room temperature for tempering. This experiment used BRRI dhan71 and BRRI dhan82 as the parboiled condition, which had moisture contents of 9.1%, 10.2%, 11.3%, 12.3%, 13.2%, 13.9% (wb.) and 9.2%, 10.3%, 11.2%, 12.3%, 13.2%, 14.1% (wb.), respectively. An Engelberg Huller air blow-type milling machine operating at 1043 rpm was used for the milling operation. A 20 kg sample was used with three replications in the study. During the milling operation, data were collected on head rice (%), broken rice (%), milling recovery (%), and milling capacity (kg/hr).

### 2.2 Performance evaluation

The moisture content of the grain was assessed using a moisture meter (Rice Ter D, Kett, England). Thousand-grain mass (TGM) was determined by counting 1000 grains for each variety using both machines and hands, followed by weighing them using a precision digital scale. Rubber rolls and husk aspirator blower fan rpm were measured using a laser photo/contact Tachometer (EXTECH model 461995, USA). The different milling parameters were calculated with the following formula:

#### 2.2.1 Husking efficiency

The percentage of the total mass of milled rice (head and broken rice) recovered from the mass of the corresponding input paddy to the rice mill (husker or huller and whitener). It is also called total milling recovery.

$$\text{Husking efficiency \%} = (\text{Weight of milled rice}) / (\text{Weight of rough rice}) \times 100$$

#### 2.2.2 Percentage of head rice

The main aim of the milling process is to get maximum head rice yield. Rice kernels three-quarters or more extended than the original kernels obtained after complete milling are termed head rice. Head rice is two to three times costlier than broken rice. Head rice yield (HRY) can be defined as the ratio of the weight of milled rice kernels obtained to the percentage of the weight of rough rice or paddy [4].

$$\text{Percentage of head rice (\%)} = (\text{Weight of head rice}) / (\text{Weight of rough rice}) \times 100$$

### 2.2.3 Percentage of broken rice

The percentage of broken rice recovered from the mass of the corresponding input paddy to the rice mill.

$$\text{Percentage of broken rice (\%)} = (\text{Weight of broken rice}) / (\text{Weight of rough rice}) \times 100$$

### 2.2.4 Percentage of husk

According to the husk percentage recovered from the mass of the corresponding input paddy to the rice mill.

$$\text{Percent hush (\%)} = (\text{Weight of husk}) / (\text{Weight of rough rice}) \times 100$$

### 2.2.5 Degree of milling (DoM)

According to Milled rice, quality determines its degree of milling. It can be defined by measuring the remaining amount of bran on the surface of milled rice kernels or by assessing the extent of the germ or bran removal from brown rice kernels during various milling operations. A gravimetric DoM was measured using an equation [16].

$$\text{Degree of milling (\%)} = (1 - (\text{Weight of milled rice}) / (\text{Weight of brown rice})) \times 100$$

## 3. Results and Discussion

### 3.1 Physical properties

Table 1 presents the physical properties of two rice varieties, BRR1 dhan71 and BRR1 dhan82. The milling outturn, which represents the percentage of grain recovered after milling is slightly higher for BRR1 dhan82 (71%) compared to BRR1 dhan71 (70%). The length of the grains differs marginally, with BRR1 dhan71 measuring 5.8 mm and BRR1 dhan82 measuring 5.5 mm. The length-to-breadth ratio, an indicator of grain shape, is 2.8 for BRR1 dhan71 and 2.2 for BRR1 dhan82, suggesting that BRR1 dhan71 has a more elongated shape compared to the relatively broader grains of BRR1 dhan82. Despite these differences, both varieties are categorized as "medium bold" in size and shape, indicating a similar overall classification within the medium grain category.

Table 1. Physical properties of BRR1 dhan71 and BRR1 dhan82.

Parameter	BRR1 dhan71	BRR1 dhan82
Milling Outturn (%)	70	71
Length (mm)	5.8	5.5
Length/Breadth Ratio	2.8	2.2
Size and Shape	Medium bold	Medium bold

### 3.2 Milling capacity and yield

For parboiled BRR1 dhan71, the air blow type Engelberg huller's milling capacity ranged from 350 to 380 kg/hr. The milling yield was found to be 67.5%, 68.0%, 68.6%, 69.2%, 70.0%, and 70.5% for moisture contents of 9.1%, 10.2%, 11.3%, 12.3%, 13.2%, and 13.9% (wb.) shown in Table 2.

Table 2. Milling capacity and milling yield of parboiled BRR1 dhan71 in the air-blow Engelberg huller

Moisture content (wb.) (%)	BRR1 dhan71	
	Capacity of Polisher, kg/hr	Milling yield, %
9.1	350	67.5
10.2	357	68.0
11.3	364	68.6
12.3	370	69.2
13.2	374	70.0
13.9	380	70.5

The milling capacity of air blow type Engelberg huller ranged from 351 to 370 kg/hr for parboiled BRR1 dhan82. Milling yield for moisture content of 9.2%, 10.3%, 11.2%, 12.3%, 13.2%, and 14.1% (wb.) was found to be 67.0%, 67.5%, 68.0%, 69.0%, 70.5%, and 70.5%, respectively (Table 3).

Table 3. Milling capacity and milling yield of parboiled BRRI dhan82 in the air blow Engelberg huller

Moisture content (wb.) (%).	BRRI dhan82	
	Capacity of Polisher, kg/hr	Milling yield, %
9.2	340	67.0
10.3	343	67.5
11.2	346	68.0
12.3	350	69.0
13.2	352	70.5

The relationship between moisture content and milling yield in rice processing is essential for optimizing efficiency and maximizing the quantity and quality of the milled rice. Optimal moisture levels play a crucial role in achieving a higher milling yield, representing the milling process's efficiency in extracting head rice from paddy. Moderate moisture content in rice grains enhances their pliability during milling, reducing breakage and minimizing grain loss. Inadequate moisture content can increase grain brittleness, making them more prone to breakage and reducing the milling yield. On the other hand, excessive moisture levels may cause grains to stick together, hindering milling and resulting in lower yield [17]. Therefore, maintaining precise moisture levels is vital for optimizing milling yield in rice processing. In Table 2, it was found that for BRRI dhan71, the increase in moisture content increased the milling yield within a certain level. This happened due to the over-moisture content; every variety has its milling yield. A similar result was also observed for BRRI dhan82, shown in Table 3.

### 3.3 Milling Parameters

The relationship between the head rice yield and moisture content in milling rice is crucial for determining the quality and efficiency of the milling process. Optimal moisture content is essential for achieving maximum head rice yield. This moisture level ensures the rice grains are pliable enough for milling without excessive breakage. Deviations from this optimal moisture range can significantly impact milling efficiency and head rice yield. If the moisture content increases, grains may become more complex, leading to increased breakage during milling. Conversely, if the moisture content is too high, grains may become too soft, resulting in elevated breakage levels and reduced head rice yield. Head rice recovery (based on input paddy) of BRRI dhan71 was found to be 59.0%, 63.0%, 62.5%, 60.0%, 58.8%, and 56.6% for the same moisture content (Table 4). Higher head rice recovery was found at 63% and 62.5%, respectively, with a moisture content of 10.2% and 11.3%.

Table 4. Milling parameters of parboiled BRRI dhan71 in the air-blow engelberg huller

Moisture content (wb.) (%).	BRRI dhan71			
	Head rice, % (Based on input paddy)	Head rice, % (Based on total milled rice)	Broken rice, % (Based on input paddy)	Broken rice, % (Based on Total milled rice)
9.1	59.0	87.4	8.5	12.6
10.2	63.0	92.60	5.0	7.40
11.3	62.5	91.10	6.1	8.9
12.3	60.0	86.7	9.2	13.3
13.2	58.8	84.00	11.2	16.00
13.9	56.6	80.20	13.3	19.80

Broken rice percentage (based on input Paddy) was found to be lower (5.0%) in 10.2% moisture content (wb.) and highest (19.80%) in 13.3% moisture content. Un-hulled paddy was not found in the milled rice processed by the air-blow type Engelberg huller. Head rice recovery (based on input paddy) for moisture content of 9.2%, 10.3%, 11.2%, 12.3%, 13.2%, and 14.1% (wb.) were found 59.0%, 62.0%, 61.2%, 60.3%, 58.0%, and 55.8%, respectively for BRRI dhan82 (Table 5). Higher head rice recovery was found at 62.0% and 61.2% in 10.3% and 11.2 % moisture content (wb.), respectively. Broken rice percentage (based on input Paddy) was found to be lower (5.5%) in 10.3% moisture content (wb.) and highest (14.7%) in 14.1 moisture content (wb.) (Table 5).

Table 5. Milling parameters of parboiled BRRI dhan82 in the air-blow engelberg huller

Moisture content (wb.) (%)	BRRI dhan82			
	Head rice, % (Based on input paddy)	Head rice, % (Based on total milled rice)	Broken rice, % (Based on input paddy)	Broken rice, % (Based on Total milled rice)
9.2	59.0	88.05	8.0	11.95
10.3	62.0	91.85	5.5	8.15
11.2	61.2	90.00	6.8	10.00
12.3	60.3	87.39	8.7	12.61
13.2	58.0	82.27	12.5	17.73
14.1	55.8	79.15	14.7	20.85

No un-hulled paddy was found in the milled rice processed by the air-blow type Engelberg huller. It was found in Table 4 that, for BRRI dhan71, moisture content 10.2 and 11.3 gave higher head rice recovery. In contrast, the other four samples containing less or more moisture content of the two specified moisture samples gave lower yields. Consequently, the two specified moisture-content paddy samples had a lower broken percentage compared to the other less or more four moisture-content samples. It was revealed in Table 5 that, for BRRI dhan82, moisture content 10.3 and 11.2 gave higher head rice recovery. In contrast, the other four samples containing less or more moisture content of the two specified moisture samples gave lower yields.

### 3.4 Degree of Milling

Paddy or rough rice, when de-husked, yields brown rice, which has an outer layer collectively called the bran/aleurone layer. The extent to which bran is removed during milling is called rice's degree of milling (DoM). The DoM affects rice quality in many ways. As the bran layer has a different composition, the DoM affects the chemical composition of rice. Fat gets smeared on the grain surface during partial milling; hence, DoM affects rice flow, packing properties, and storage stability. Many micronutrients are concentrated in the bran layer; therefore, the DoM of rice affects its nutritive value. Decreased DOM of rice after parboiling may be attributed to more bran removal from un-parboiled rice than parboiled rice [18], because parboiling increases the milling resistance of rice [19]. DoM affects cooking, too, as the bran layer offers some resistance to cooking. The inherent properties of rice and grain determine the quality of the milled rice. Optimal moisture content is fundamental for achieving a high degree of milling and maximizing milling yield. The degree of milling, often quantified by the percentage of head rice obtained after processing, is directly influenced by moisture. For BRRI dhan71 and BRRI dhan82, DoM increases with moisture content within a specific limit (Figures 1 & 2). In this experiment, degree milling was kept below 10% by keeping the same weight for different moisture content in the rice delivery outlet of air blow type Engelberg huller for the BRRI dhan71 and BRRI dhan82 content.

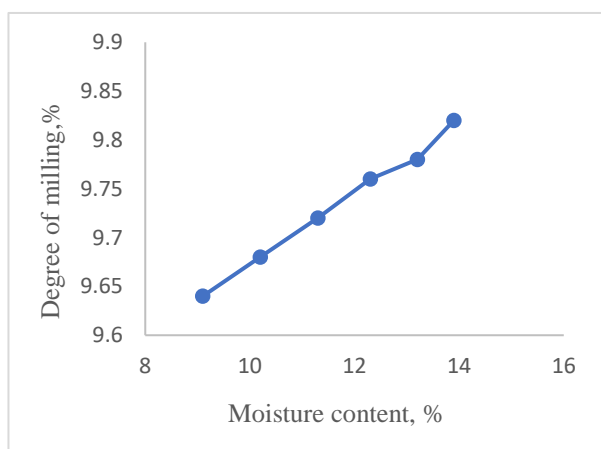


Figure 1. Relationship between moisture content and Degree of milling of BRRI dhan71 (wb.)

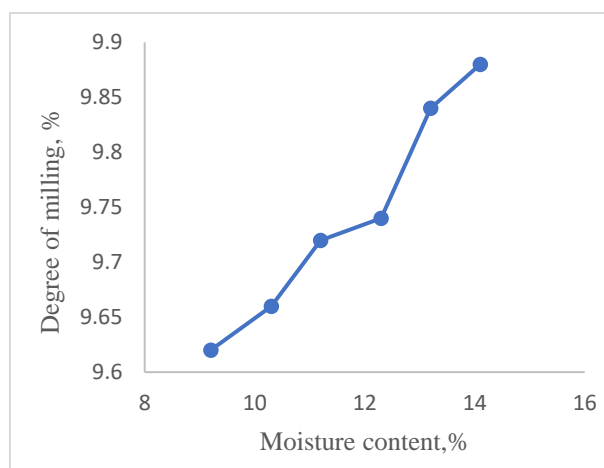


Figure 2. Relationship between moisture content and Degree of milling of BRRI dhan82 (wb.)

#### 4. Conclusions

This study investigated the effect of moisture content on the milling yield of two parboiled rice varieties (BRRI dhan82 and BRRI dhan71) using an air-blow type Engelberg huller. The results revealed that a moisture content of 10.2-11.3% (wet basis) yielded the highest head rice recovery (around 62%) for both varieties. Lower moisture content increased in broken rice. Notably, the milling process effectively removed all hulls. These findings suggest that maintaining a moisture content of 10-11% during milling with this specific huller type optimizes head rice yield while minimizing breakage. This information provides valuable insights for parboiled rice producers, potentially leading to improved overall efficiency in parboiled rice production. Adopting this optimal moisture content level can save rice producers significant costs and increase profitability. Further research could explore the applicability of these findings to other parboiled rice varieties and huller types.

#### Acknowledgement

The author would like to thank all the scientists of FMPHT and WMM Division, BRRI. They are acknowledged for their kind cooperation and encouragement throughout the research.

#### References

1. Nath B, Hossen M, Islam A, Huda M, Paul S, Rahman M. Postharvest loss assessment of rice at selected areas of Gazipur district. *Bangladesh Rice Journal*. 2016;20(1):23-32.
2. Paul H, Nath B, Bhuiyan M, Paul S, Islam S, Huda M, et al. Effect of degree of milling on rice grain quality. *Journal of Agricultural Engineering*. 2019;42(4):69-76.
3. Nath B, Chen G, O'Sullivan CM, Zare D. Research and Technologies to Reduce Grain Postharvest Losses: A Review. *Foods*. 2024;13(12):1875. PubMed PMID: doi:10.3390/foods13121875.
4. Yadav B, Jindal V. Changes in head rice yield and whiteness during milling of rough rice (*Oryza sativa* L.). *Journal of Food Engineering*. 2008;86(1):113-21.
5. Li Y, Cao C, Yu Q, Zhong Q. Study of rice fissuring during intermittent drying. *Dry Tech*, 17 (9). 1779;1793.
6. Lyon BG, Champagne ET, Vinyard BT, Windham WR, Barton FE, Webb BD, et al. Effects of degree of milling, drying condition, and final moisture content on sensory texture of cooked rice. *Cereal Chemistry*. 1999;76(1):56-62.
7. Bhuiyan M, Huda M, Nath B, Islam A, Islam M, Islam S. Performance evaluation of modified rubber roll De-husker. *Journal of Agricultural Engineering*. 2020;43(1):31-9.
8. Nath BC, Huda MD, Rahman MM, Paul S. Essential Steps for Developing Rice Harvest Mechanization in Bangladesh. *Cutting-edge Research in Agricultural Sciences Vol 7*. 2021:109-25.
9. Nasirahmadi A, Emadi B, Abbaspour-Fard MH, Aghagolzade H. Influence of moisture content, variety and parboiling on milling quality of rice grains. *Rice Science*. 2014;21(2):116-22.
10. Nath B, Nam Y, Huda M, Rahman M, Ali P, Paul S. Status and Constrain for Mechanization of Rice Harvesting System in Bangladesh. *Agricultural Sciences*. 2017;08(06):492-506. doi: 10.4236/as.2017.86037.
11. Khan MAR, Mahmud A, Islam MN, Ghosh UK, Hossain MS. Genetic variability and agronomic performances of rice genotypes in different growing seasons in Bangladesh. *Journal of Agriculture and Food Research*. 2023;14:100750.
12. Huda M, Nath B, Paul S, Bhuiyan M, Islam S, Islam M. Design and development of a head feed mini combine harvester suitable in Bangladesh condition. *Journal of Agricultural Engineering*. 2019;42(2):73-92.
13. SUMON M. EXPLORATION OF GENETICAL PURITY, YIELD PERFORMANCE AND GRAIN QUALITY OF SLENDER GRAIN HYBRID T. AMAN RICE. DEPARTMENT OF AGRONOMY, 2020.
14. Shozib H, Hossain M, Jahan S, Alam M, Das S, Alam S, et al. Study of biochemical and cooking quality traits of major rice varieties of Bangladesh. *Malaysian Applied Biology*. 2017;46(4).
15. Ali N, Pandya A. Basic concept of parboiling of paddy. *Journal of Agricultural Engineering Research*. 1974;19(2):111-5.
16. Curtin D, Beare MH, Hernandez-Ramirez G. Temperature and moisture effects on microbial biomass and soil organic matter mineralization. *Soil Science Society of America Journal*. 2012;76(6):2055-67.
17. Singh SM, Rao PS. Impact Dehulling of Browntop Millet: Its Physical and Nutritional Characterization. *Journal of Cereal Science*. 2024:104078.
18. Miah MK, Haque A, Douglass MP, Clarke B. Parboiling of rice. Part I: Effect of hot soaking time on quality of milled rice. *International journal of food science & technology*. 2002;37(5):527-37.
19. Gujral HS, Singh J, Sodhi NS, Singh N. Effect of milling variables on the degree of milling of unparboiled and parboiled rice. *International Journal of Food Properties*. 2002;5(1):193-204.