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# Comparative study of properties of basmati and non- basmati rice in India.

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**Abstract**

The aim of this study was to analyze the Physicochemical, cooking, textural and milling properties of different basmati and non-basmati rice cultivars. **Materials and methods.** The de-husking and milling of the paddy were performed using a laboratory mill, and the head rice recovery was determined using Adair's methods. The milled rice was analyzed for moisture, ash, protein, and amylase content. The textural attributes of cooked grains were analyzed using Texture Profile Analysis. **Results and discussion.** The study presented the milling and chemical properties of different rice cultivars, which affect the quality and market value of rice. Basmati varieties had significantly lower starch content and higher amylose content than the non-basmati cultivar. In terms of physical properties, the bulk density measurements showed that PB-6 had the lowest bulk density, while P-44 had the highest bulk density. When it came to true density, P-2819 stood out with the highest value. Additionally, the study found that basmati varieties tended to have longer grains compared to non-basmati varieties. Furthermore, when examining the length-to-breadth ratio, PB-1121 stood out with the highest ratio, suggesting a relatively slender and elongated grain shape. The cooking properties of the rice cultivars investigated in the study revealed interesting variations. P-2819 demonstrated the shortest cooking time, whereas PB-1121 showed the longest cooking time. The elongation ratio was found to be higher in basmati varieties compared to non-basmati varieties. When considering water uptake, PB-1121 exhibited the highest ratio, implying that it absorbed more water during cooking. Additionally, the solid loss was highest in P-2819 and lowest in PB-1121. In reference to textural properties, P-2819 exhibited the highest hardness, whereas PB-1121 had the lowest. The adhesiveness of the non-basmati variety was higher than that of the basmati variety, indicating a stickier texture. PB-1121 had the lowest gumminess, indicating a lesser tendency for the grains to become gummy. The correlation study revealed significant relationships between rice properties. Cooking time correlated positively with true density, length to breadth ratio, hardness, gumminess, and chewiness. Elongation ratio correlated positively with amylose content, porosity, length, length to breadth ratio, and 1000 kernel weight. Water uptake ratio showed multiple positive correlations

## Introduction

Rice is a crucial cereal crop that serves as a staple food for more than half of the world's population, providing 20% of its dietary energy supply. With approximately 95% of its production in Asia, rice comes in countless varieties, with India being a significant contributor. Basmati rice, which constitutes only 1% of India's total rice production, is a registered geographical indicator product of India known for its characteristic aroma, exceptional cooking and textural properties, and unique flavor due to the hydrolysis of starch. Basmati rice is considered one of the most acceptable classes of rice globally, especially for its soft and fluffy texture, and is an outstanding example of long-grain flavor rice varieties. Non-basmati rice, on the other hand, is rice that does not have the characteristics of basmati rice, which can have diverse shapes and sizes such as long-slender, short-thick, beads, or even round, with properties entirely different from basmati rice. Researchers have studied various rice varieties, including their physical properties, milling characteristics, physicochemical properties, and cooking characteristics to establish the differences between the various cultivars grown worldwide. Moreover, physicochemical and cooking properties of rice cultivars from Pakistan and found significant differences in amylose content, water uptake, and cooking time (Murtaza et al., 2022). With the increasing demand for rice globally, there is a tremendous amount of scope to carry out further research on different rice cultivars to improve their yield, quality, and nutritional content to meet the growing needs of the population.

Consumer acceptance of rice is influenced by the milling degree, i.e. the percentage of bran removed from the brown rice grain. Milling produces white rice with a higher market value than brown rice. Besides influencing the color, the milling degree also improves the cooking behavior of rice. Brown rice has poor water absorption capacity and cooks slower than white rice. In general, 'head rice' comprises kernels that are 75-80 percent of the whole kernel. The quality of milled rice is measured on the yield of 'head rice'. The market value of 'broken' is reduced to about half that of head rice and the milling process is one of the factors responsible for brain damage and loss besides losses caused due to harvesting, drying or handling (Nzonzo and Mogambi, 2016). One of the exceptional characteristics of basmati rice cultivars is kernel elongation during cooking, which has a complex inheritance pattern. Other important basmati features- aroma and slenderness are effortlessly inherited and simple to transfer. Consumers prefer rice that is elongated in length when cooked. The phenomenon of elongation is influenced by numerous genetic or physicochemical factors, including genotypes, ageing temperature, ageing time, water uptake, amylose content and gelatinization temperature (Faruq and Prodhan, 2013).

The physicochemical properties like grain weight and size, including the length, breadth and length: breadth ratio, damaged rice, moisture, ash, protein, starch and amylose content, have a significant impact on the marketing value of rice. Grain size and shape are the properties that vary with the variety of grain under consideration. Determination of the physical properties of the grain, including dimensional analysis, bulk density and thousand grains weight, is essential for the design and development of storage bins that help prevent spoilage by molds and insect infestation (Pandiselvam et al., 2015). Thus, the physicochemical, organoleptic and cooking properties are very significant for the consumers to evaluate the superiority and preference of rice (Verma and Srivastav, 2020). Moreover, the physicochemical properties and amylose content collectively determine rice's thermal/ cooking quality (Sujatha et al., 2004). Water uptake is conventionally defined as the grams of water absorbed per gram of rice in a given time when rice is cooked directly in boilingwater. It is affected by grain surface area per unit weight. Therefore, more petite and more slender grains would cook in a shorter period than bigger and rounder grains. Soaking before cooking not only cuts down cooking time but also enhances kernel elongation. Bhattacharya (2011) reported that water uptake, which is influenced by grain surface area per unit weight, affects the cooking time and kernel elongation of rice. The author also noted that soaking before cooking enhances kernel elongation and reduces cooking time. Concerning this, the present study evaluated the essential properties of certain developed Indian rice cultivars.

## Materials and methods

### Materials

The Indian Agricultural Research Institute, Pusa, Delhi, provided four paddy cultivars, including two non-basmati (P-44 & P-2819) and two basmati (PB-1121 & PB-6), for this study.

### De-husking and milling of paddy

The paddy seeds of various selected cultivars were hulled using a laboratory model of Paddy de husker and the milling was performed with a rice miller (McGill type, Osawa Industries Pvt. Ltd, India). After de-husking, the percentage of husk and recovery of rice grain were measured and after milling, the head rice recovery was determined using Adair's methods (Adair, 1952).

### Chemical properties of milled rice

Moisture, ash and protein content of different cultivars of milled rice grain were determined using the standard analysis methods (AOAC, 2000). Amylose content was determined by using the method of Juliano (1971) with some minor modifications. 0.1 g of rice flour was taken in a test tube and 1 mL ethanol (95%) and 9 mL of 1N sodium hydroxide were added. The samples were heated in a boiling water bath, cooled for about one h, and the final volume was made up to 100 mL with distilled water. 5 mL of this sample solution was taken in a test tube and 1 mL of 1 N acetic acid followed by 2 mL of iodine solution were added into it and the absorbance of the solution was measured at 620 nm.

### Physical properties of rice kernel

The dimensional parameters such as grain length (L) and breadth (B) of milled rice were measured with vernier calipers. The measurement was performed by using 10 grains in each sample; thus, averages of 10 grains were recorded. The ratio of length and breadth (L/B) ratio, was also determined for milled rice (Kaur et al., 2011). The Gravimetric properties viz., 1000 kernels weight of each sample was determined by counting randomly selected 1000 kernels. The bulk density was determined using the mass/volume relationship. It was determined by tenderly pouring the grains into a 100 mL graduated cylinder and it was weighed. The actual density was determined using the kerosene displacement method by immersing a weighted quantity of rice grains in the known volume of kerosene. Porosity (%) was estimated with the help of values obtained from bulk and true density and by using the following equation:

The cooking properties of milled rice were observed using the method of Yadav et al. (2014). The milled head rice (2 g) of each cultivar was cooked with 20 mL distilled water, taken in a test tube of 50 mL and cooked in a boiling water bath. The cooking time was determined by analyzing a few grains at different time intervals during cooking till no white core was left. The elongation ratio of rice grain was measured by dividing the length of cooked grain by the length of the uncooked grain. To determine water uptake, the weight of cooked rice and uncooked rice was measured carefully, and water absorption was determined based on water gained after cooking. Solid loss in gruel was measured by completely drying left-out cooking water in a hot air oven at 105 ºC.

**Results and discussion**

**Milling and chemical properties of various rice cultivars**

The market value of rice generally depends on its milling performance because of the total recovery; the proportion of head and broken rice categorizes its quality. The milling properties of rice cultivars are presented in Table 1; after milling, various properties like husk percentage, milled rice and head rice percentage were observed. Maximum husk percentage was measured in PB-1121 and P-2819; minimum was estimated in PB-6, followed by PB-44. Reciprocally, the recovery of milled rice was observed maximum in PB-6. In terms of head rice recovery most excellent recovery (71.77%) was calculated for P-44 and significantly least (63.23%) recovery was observed for PB-6. Sandhu et al. (2018) also reported that milling recovery varied from 49.43% to 77.08% for some Indian rice varieties. Similarly, Falade and Christopher (2015) observed that milling recovery varied from 45.74% to 68.24% for six Nigerian rice cultivars. They also reported that a recovery equal to or less than 50% is undesirable. Moreover, similar milling properties of different rice varieties were reported in earlier studies (Kaur et al., 2011; Rather et al., 2016; Verma and Srivastav, 2020). A studies conducted by Li et al. (2021) and Ertop et al. (2020) examined the impact of millingdegree on the physical and chemical properties of rice flour, and found that the milling process significantly affects the flour quality. Similarly, a study by Yuliana et al. (2020) investigated the milling characteristics and physicochemical properties of Indonesian rice varieties, and found that the milling efficiency has a significant impact on the head rice yield and total milling recovery. The study revealed that the more efficient milling process resulted in a higher total milling recovery, indicating that a larger quantity of milled rice was obtained from the same amount of raw paddy. Moreover, research by Sandhu et al. (2018) and Falade and Christopher (2015) provides evidence of the significant variation in milling recovery among different rice cultivars. In their studies, milling recovery was found to range from45.74 to 77.08% for six Nigerian rice cultivars and from 49.43 to 77.08% for some Indian rice varieties. A recovery equal to or less than 50% was deemed undesirable by Falade and Christopher, further highlighting the importance of milling performance in determining rice quality and market value.

The chemical properties such as moisture, ash, protein, starch and amylose of the milled rice grain are presented in Table 1. The moisture content was estimated in the range of 10.75 to 11.84%. Previous studies have conducted moisture content analysis on various rice cultivars, revealing a range of values across different investigations. For instance, Elbashir (2005) reported moisture contents ranging from 8.6 to 10.9% in their study. Similarly, Kaur et al. (2011) found moisture contents between 10.05 and 12.61% in another research, while He et al. (2021) observed moisture contents ranging from 11.15 to 13.40% in their study. The ash content was measured maximum in PB-1121 and significantly lower was observed for P- 2819. No trend of difference in ash contents was observed between basmati and non-basmati varieties, as reported by Kaur et al. (2011). However, their tested varieties ranged between 0.24 to 0.62% ash content, while Verma and Srivastav (2020) ranged between 0.48 to 0.85% in different varieties of rice. The protein content was observed in the range of 5.87 to 7.27%, and it was observed highest for cultivar PB-6 and lowest for P-2819. Several studies have investigated the protein content of various rice cultivars, providing valuable insights into the range of protein levels observed.

For instance, Elbashir (2005) reported protein content ranging from 6.2% to 8% in different rice cultivars. In another study by Verma and Srivastav (2020), protein content in aromatic rice varieties was found to be within the range of 7.23 to 9.51%. Similarly, Sandhu et al. (2018) observed protein content ranging from 7.92 to 8.02% in short and long grain Indica rice cultivars. Starch content was observed to be higher for non-basmati cultivars, i.e. P-2819 and P-44 and lower for basmati cultivars, i.e. PB-6 and PB-1121.

The amylose content usually has considerable effects on the cooking characteristics and eating quality of rice apart from being a significant decider of the textural properties (hardness and adhesiveness) of cooked rice (Suwannaporn et al., 2007). The amylose content was significantly lower for variety P-44 and highest for variety PB-1121. The amylose content is an ancillary characteristic of rice and should range from 20–25% for basmati varieties. Ahuja et al. (1995) reported amylose content in different basmati rice varieties cultivated in India, ranging from 19.10 to 27.14%. This amylose content was in accordance with non-aromatic IRRI (International Rice Research Institute) varieties. The amylose content in non-aromatic rice varieties can range from around 20% to over 30%, depending on the specific variety and growing conditions (Butardo et al., 2019). Physical properties of different varieties of milled rice Grading of rice grain based on physical characteristics such as length, breadth, density, and porosity is crucial for consumer acceptance of a particular variety. In Table 2, the physical properties of four different varieties of milled rice are presented. The bulk density (BD) was found to be the lowest for variety PB-6 and the highest for P-44, indicating that longer grains have a lower bulk density, and PB-6 would require more storage space while P-44 would require the least. The true density was observed to be significantly higher in P- 2819, which is consistent with findings reported by Kaur et al. (2011) for different rice cultivars grown in India. The relationship between bulk density and true density is presented in the form of porosity, and it was observed that basmati varieties have a higher value than non-basmati varieties, which agrees with previous studies (Singh et al., 2005). The lengths of all the varieties ranged from 7.10 to 7.80 mm, with lower values observed for non-basmati varieties and higher values for basmati varieties. Similar results were observed in different previous studies of basmati and non-basmati cultivars (Kaur et al., 2011A length to breadth (L/B) ratio is used to classify the shape of rice grains; the higher value of the L/B ratio indicates slender shapes, whereas intermediate, medium, round or bold shapes of grains are indicated by a lower L/B ratio (Verma and Srivastav, 2020).

**Cooking properties of different varieties of milled rice grains**

The present study evaluated the cooking properties of various milled rice grains and reported the results in Table 3. The cooking time varied significantly among the different rice varieties, with the lowest cooking time (22.83 min) observed for P-2819 and the highest cooking time observed for PB-1121. The elongation ratio was also found to vary significantly, with basmati varieties exhibiting significantly higher values than non-basmati ones. The Seed Act 1966 states that the minimum elongation ratio of basmati rice should be 1.70.

**Textural properties of cooked rice grain**

Texture profile analysis (TPA) is a widely used method for evaluating the textural properties of rice the results of presented study is embedded in Table 4. Hardness was significantly higher for P-2819, and the lowest was estimated for PB-1121. Adhesiveness is the negative area for the first compression cycle representing the work needed to overcome the attractive forces between the probe and food and it was calculated higher for non-basmati variety when compared to basmati variety. The hardness of rice rich in amylose rice was mainly attributed to leached amylose, which forms several layers of thick coating on the cooked rice (Yu et al., 2009). Previous investigations have also proven that rice with low amylose content would have a soft texture, while waxy rice would exhibit a hard, adhesive, and sticky texture (Moongngarm et al., 2012; Tao et al., 2020). The researchers also observed increasing hardness with an increase in amylose content. Li (2017) showed that rice with comparable amylose contents could exhibit different textural attributes. Besides, they may have the same texture even with utterly different amylose contents, possibly due to complexities in characterizing the structure of amylose. Springiness was measured in the range from 0.02 to 0.03.

Cohesiveness is the ratio of the positive force area during the second cycle of compression to that of the first cycle, which was estimated from 0.48 to 0.55. Gumminess is the product of hardness and cohesiveness; it was observed significantly lower for variety PB- 1121, whereas significantly higher was measured for P-2819. The chewiness is the product of gumminess and springiness, and similar to gumminess, the maximum was calculated for P-2819 and the minimum was reported for PB-1121. No significant difference was observed for resilience among different cultivars of a cooked rice grain, and it was observed in the range from 1.03 to 1.31. Similar results of textural properties of cooked rice grains were observed by Sethupathy et al. (2021), who found that the hardness, adhesiveness, and gumminess of rice grains varied significantly among different cultivars.

**Correlation study**

The correlation investigation was established among different physical, chemical, cooking and textural properties (Table 5 A-B). Cooking time showed a highly significant and positive correlation with true density and L/B ratio, whereas there was a negative correlation with solid loss, hardness, gumminess and chewiness. Elongation ratio showed a highly significant positive correlation with amylose content (r= 0.802) and porosity (r= 0.741), whereas there was a negative correlation with total starch and bulk density. Water uptake ratio showed a significant ($P \leq 0.01$) positive correlation with amylose content, true density, porosity, length, L/B ratio and 1000 KW. Solid loss indicated a significantly higher correlation with total starch, hardness and chewiness. Total starch showed a significant ($P \leq 0.05$) positive correlation with bulk density, width and hardness. Moreover, amylose content showed a higher significant positive correlation with true density, porosity, length, 1000KW and adhesiveness. Interestingly, no positive correlation was observed between bulk density and other parameters. True density showed a significant ($P \leq 0.01$) positive correlation with porosity, length, L/B ratio and 1000KW.

Porosity showed higher significant and positive correlation with length (r = 0.813) and 1000KW (r =0.777). The length of uncooked grains was highly correlated with the L/B ratio and 1000KW. A strong positive correlation was established between the L/B ratio and 1000KW. The hardness of cooked rice grain demonstrated a higher significant and positive correlation with gumminess (r = 0.816) and chewiness (r = 0.896). From this correlation study, it was measured that the increase in the cohesiveness of cooked rice grain is due to an increase in the springiness, whereas gumminess was observed directly related to the chewiness of cooked rice grain. The given correlation investigation among different physical, chemical, cooking, and textural properties is supported by several previous studies. For example, a study conducted by Bhardwaj et al. (2019) reported a significant positive correlation between elongation ratio and amylose content in rice. Similarly, a study by Wang et al. (2010) also reported a positive correlation between amylose content and water uptake ratio in rice. Moreover, the positive correlation between true density and cooking time is also supported by a study by Pokhrel et al. (2020). The negative correlation between solid loss, hardness, gumminess, chewiness, and cooking time is also reported in a study by Zhu et al. (2020). Furthermore, the positive correlation between total starch and hardness is supported by a study by Li and Gilbert (2018). The positive correlation between amylose content and true density, porosity, length, 1000KW, and adhesiveness is also supported by studies by Verma and Srivastav (2020).

**Conclusions**

1. Milling performance, as indicated by the recovery of milled rice and head rice recovery, varied among the cultivars. PB-6 exhibited the highest milled rice recovery, indicating better milling efficiency, while PB-1121 had the lowest recovery. P-44 had the highest head rice recovery, suggesting a higher percentage of intact rice grains, whereas PB-6 had the lowest head rice recovery.
2. The chemical composition of milled rice also differed among the cultivars. Moisture content ranged from 10.75 to 11.84%, indicating similar moisture levels across the varieties. PB-1121 had the highest ash content, which may affect the nutritional composition and sensory attributes of rice. Protein content varied from 5.87 to 7.27%, with PB-6 exhibiting the highest protein content. Starch content was higher in non- basmati cultivars compared to basmati cultivars, indicating potential differences in cooking and texture. PB-1121 had the highest amylose content, which may contribute to its characteristic texture and cooking properties.
3. Physical characteristics, including length, breadth, density, and porosity, are important factors influencing consumer acceptance. Basmati varieties generally displayed higher length, lower breadth, and higher length-to-breadth (L/B) ratio compared to non- basmati varieties, contributing to their desirable appearance. PB-1121 had the highest L/B ratio among the cultivars. Bulk density was lowest for PB-6 and highest for P-44, while true density was highest in P-2819, indicating differences in grain compactness.
4. Cooking properties varied among the rice varieties, with P-2819 exhibiting the lowest cooking time and PB-1121 showing the highest cooking time. Basmati varieties displayed higher elongation ratio and water uptake ratio compared to non-basmati varieties, indicating their ability to absorb more water and elongate during cooking. P- 2819 had higher solid loss, which might affect its overall texture, while PB-1121 had lower solid loss, indicating a firmer texture after cooking.
5. Textural properties, such as hardness, adhesiveness, and gumminess, also differed among the cultivars. P-2819 exhibited the highest hardness and gumminess, potentially resulting in a chewier texture, while PB-1121 had the lowest hardness, suggesting a softer texture. Adhesiveness was higher in non-basmati varieties compared to basmati varieties, indicating variations in stickiness.
6. The correlation analysis provided insights into the relationships between different properties of rice grains. Cooking time positively correlated with true density and L/B ratio, suggesting that denser and elongated grains require longer cooking. Conversely, cooking time showed negative correlations with solid loss, hardness, gumminess, and chewiness, indicating that softer and less sticky grains tend to cook faster. Elongation ratio showed positive correlations with amylose content and porosity, indicating that higher amylose content and increased porosity contribute to greater elongation during cooking. Water uptake ratio displayed positive correlations with amylose content, true density, porosity, length, L/B ratio, and 1000 kernel weight, suggesting that these factors influence the water absorption capacity of rice grains.

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