Physicochemical Characterization and Cooking Quality Assessment of Indigenous Traditional Rice Varieties

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Abstract

The current study evaluated the physical and cooking qualities of three traditional rice varieties from Tamil Nadu: Mappillai Samba, Seeraga Samba, and Sivapu Kavuni. We analyzed their grain size, bulk density, true density, porosity, moisture content, 1000-grain weight, alkali spreading value, and cooking behavior. There were notable differences among the varieties in both physical and cooking traits. Sivapu Kavuni had the largest grain size (length 5.72 mm, breadth 1.84 mm) and true density (1.30 g/cm³), showing a denser endosperm structure. Mappillai Samba had the highest bulk density (0.3952 g/cm³), while Seeraga Samba had the lowest 1000-grain weight (8.467 g) due to its fine grain size. The alkali spreading value indicated that Seeraga Samba had a higher gelatinization temperature, while Mappillai Samba and Sivapu Kavuni had lower gelatinization temperatures, leading to shorter cooking times. In the cooking quality assessment, Sivapu Kavuni had the highest water absorption ratio (3.5 g) and elongation after cooking. Meanwhile, Seeraga Samba had a firm texture and aromatic flavor, making it ideal for biryani. These findings highlight the unique physical and cooking traits of traditional rice varieties, emphasizing their importance for nutrition, culture, and commerce. Encouraging their growth and use can help promote sustainable agriculture and protect regional food traditions**.**

Keywords: Traditional rice varieties, Cooking properties, Physical properties.

Introduction

Rice (*Oryza sativa* L.) is the staple food for more than half of the global population, and in India it forms an integral part of the daily diet, cultural heritage, and traditional medicine (Khush, 2005). Among the vast diversity of rice germplasm in India, traditional landraces hold a special place due to their unique nutritional profile, sensory qualities, and adaptability to local agro-climatic conditions. Unlike high-yielding modern varieties, traditional rice cultivars are often valued for their distinct flavor, texture, and health-promoting attributes, which are closely linked to their cooking properties (Sweeney & McCouch, 2007). Major traditional rice varieties grown in Tamil Nadu includes Seeraga Samba, Mappilai Samba, Kichadi Samba, Sivapu Kavuni, Karupu Kavuni etc. These are valued for their unique aroma and are mainly cultivated in regions with suitable irrigation and traditional farming practices.

Seeraga Samba is prized for its fine, slender grains and exceptional aroma, commonly used in festive biryanis and special dishes. Mappilai Samba, historically consumed by warriors for strength and stamina, is rich in dietary fiber, iron, and other minerals, and has been reported for its nutraceutical potential (Balasubramanian & Rani, 2017). Sivapu Kavuni, a pigmented rice with deep red-purple coloration due to the presence of anthocyanins, is considered a functional food with antioxidant, anti-inflammatory, and medicinal properties (Sompong *et al*., 2011; Shao *et al*., 2018).

The physical properties such as length,breadth ,L/B ratio, 1000 grain weight, true & bulk density were evaluated and the cooking characteristics of these varieties such as water absorption, gelatinization temperature, amylose content, cooking time, texture, and sensory quality play a crucial role in determining their consumer acceptance and suitability for various culinary preparations. Understanding these properties is also essential for promoting their wider utilization in modern diets, food processing industries, and value-added product development.

This study focuses on the physical and cooking properties of these rice varieties by comparing their grain characteristics and cooking behaviour. This paper aims to provide insights into the unique qualities of these traditional rice varieties and their potential value in contemporary food practices.

Materials and Methods

Traditional rice variety such as –Mappilai Samba, Seeraga Samba and Sivapu Kavuni were taken. This study was conducted to evaluate the rice grain quality based on physical properties and cooking properties that will provide highly important information for future rice breeding programs as well as for consumers

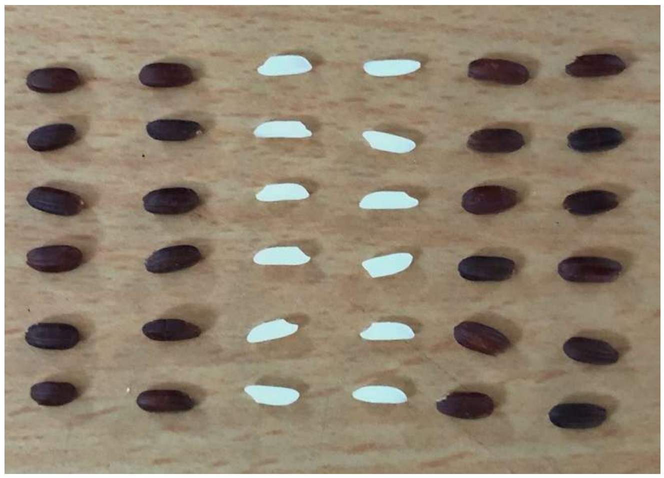

Fig.1 Mappillai samba, Seeraga samba, Sivapu kavuni

Physical properties

Kernal length and breadth

Length, breadth and thickness of the three rice varieties are determined using vernier caliper. This procedure was triplicated to ensure accurate values.

Bulk density

The bulk density was measured by weighing rice in a standard dry quart cup and dividing the weight by the cup's volume. This measurement was repeated three times with the same subsample to minimize error and ensure accuracy.(Bhattacharya and Sowbhagya, 1971).

$$\text{Bulk density}(\mathrm{g}/cm^3) = \frac{\text{weight of rice}}{volume\ of\ rice}\mathrm{x}100$$

True density

The true density of rice varieties was determined using liquid displacement method with toluene. A known weight of rice was placed into a graduated cylinder containing known volume of toluene and displaced grain volume was recorded. True density is then obtained by dividing weight of sample by the displaced grain volume and expressed as g/cm^3. (Mohsenin, N.N.,1986)

Porosity

The porosity of the traditional rice varieties under study was determined by the following formula as suggested by Mohsenin,N.N.,(1986).

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$$\text{Porosity (\%)} = \frac{true\ density - bulk\ density}{true\ density} \times 100$$

5.1000 grain weight

The 1000-grain weight was determined by taking a clean sample, carefully counting 1000 whole grains, and weighing them using an analytical balance. This procedure was repeated three times to ensure accurate results.

6. Alkali spreading value

The alkali spreading value of the rice varieties was determined to assess gelatinization characteristics (Rohilla, 2000). Ten polished rice kernels were soaked in 10 mL of 1.7% KOH solution in test tubes and incubated at room temperature for 23 hours. After incubation, the degree of spreading and disintegration of the grains was observed and scored on a scale of 1–7, where higher values indicate softer cooking rice.

7.Moisture content

Moisture content in rice was determined using the oven-drying method. A known weight of rice was dried in a hot air oven at 105 °C for 5 hours, then cooled in a desiccator and reweighed.(Azmi, N., *et al.* 2021)

$$\text{Moisture content(\%)} = \frac{initial\ weight - final\ weight}{initial\ weight} \times 100$$

Cooking properties

1. Length and Breadth after cooking

A small, measured sample of rice (about 15 g) is cooked in plenty of boiling water until it is soft for minimum time(Singh *et al*. 2005).After draining and cooling to room temperature, the length and breadth of 10 randomly selected grains are measured using a vernier caliper. The average measurements are recorded for each rice variety.

2. Linear elongation ratio

The linear elongation ratio shows how much the rice grains lengthen during cooking. It is calculated by dividing the average length of the cooked grains by the average length of the uncooked grains. This gives an idea of the cooking quality and texture of each variety(Singh *et al*., 2005).

3. Water absorption ratio

To determine how much water rice absorbs during cooking, a known weight of rice (about 15 g) is cooked until soft. The cooked rice is then weighed, and the water absorption ratio is calculated by comparing the weight before and after cooking. This reflects how much water each variety can take up (Bett-Garber *et al*., 2007).

RESULTS AND DISCUSSION

Physical properties

The rice varieties used in the present study are depicted in Figure. 1. The selected rice samples were analyzed for physical properties like length, breadth, bulk density and porosity among the selected rice varieties and were presented in Table. 1.

- The study determined and compared several physical properties of three rough rice cultivars: Mappillai samba, Seeraga samba and Sivapu kavuni, including dimensions such as length, width, thickness, and sphericity
- The findings highlighted the importance of understanding the physical properties of rice grains for various applications in the rice industry, including handling, processing, and grading

Length and breadth

Among the rice varieties studied, Sivapu Kavuni exhibited the highest grain dimensions, with a length of 5.72mm and a breadth of 1.84 mm. This was followed by Mappillai Samba, which had a length of 5.70 mm and a breadth of 1.82 mm, values that were significantly higher compared to the other varieties as Seeraga Samba had a length of 4.08mm and a breadth of 1.80mm.

Length to breadth ratio

Based on the L/B ratio, Seeraga Samba can be classified as a slender type (Singh *et al*., 2000). The observed differences in grain size, shape, and moisture content among the varieties likely contributed to the variations in length, breadth, and L/B ratio. These variations also influence the cooking behavior, texture, and overall quality of the rice, making such physical characteristics important for both consumer preference and processing. Understanding these differences can aid in selecting appropriate varieties for specific culinary and industrial purposes.

True density and Bulk density

The true density of the selected rice varieties varied slightly among the samples. Mappilai Samba recorded a value of 1.25g/ cm^3, Seeraga Samba showed a lower value of 1.20g/cm^3, while Sivapu Kavuni had the highest true density of 1.30g/cm^3. These differences may be due to variation in grain compactness and endosperm structure among the varieties. The comparatively higher true density of Sivapu Kavuni indicates denser grain packing, whereas the lower value in Seeraga Samba reflects a lighter structure.

The highest bulk density of 0.3952 g /cm^3 Mappilai Samba and 0.395130 g/cm^3 of Seeraga Samba varieties with the lowest bulk density of 0.3653 g/cm^3 in Sivapu Kavuni among traditional rice varieties.

Porosity

The true density and porosity of traditional rice varieties varied slightly among the samples. Mappilai Samba showed a true density of 1.25 g/cm^3, Seeraga Samba had 1.20 g/cm^3, and Sivapu Kavuni recorded the highest value of 1.30 g/cm^3, indicating denser grain packing. The bulk density was highest in Mappilai Samba (0.3952 g/cm^3) and Seeraga Samba (0.3951 g/cm^3), while Sivapu Kavuni had the lowest (0.3653 g/cm^3). The porosity of these varieties ranged from 60.48% to 63.48%, with Sivapu Kavuni showing the highest value (63.48%) and Seeraga Samba and Mappilai Samba showing slightly lower values (60.49% and 60.48%). The variations in porosity mainly reflected differences in bulk and true density, influenced by sssssgrain size and structure, showing no major differences among the varieties.

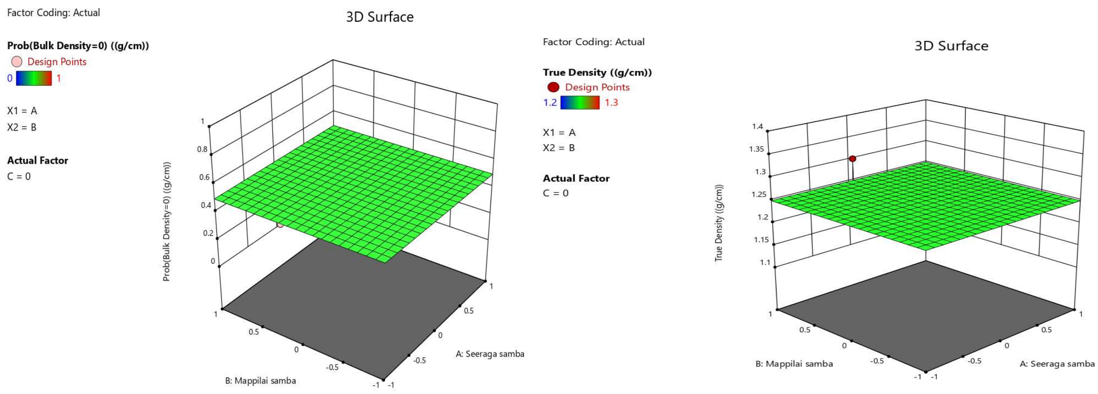

Fig.2 RSM of true and Bulk density of rice varieties

Moisture content

The moisture content of the three traditional rice varieties showed slight variations. Seeraga Samba rice exhibited a moisture content of 13%, while Mappillai Samba recorded a similar value of approximately 13%. Sivapu Kavuni rice demonstrated a slightly lower moisture content of 12.5%. These values indicate that all three varieties possess comparable moisture levels, which can influence their cooking behavior, shelf life, and storage stability.

1000 grains weight

The 1000 grain weight of the three traditional rice varieties showed significant variation, reflecting differences in grain size and density. Mappillai Samba recorded a 1000-grain weight of 22.058 g, indicating medium-sized grains with moderate density (Subramanian *et al*., 2020). Seeraga Samba exhibited the lowest 1000-grain weight at 8.467 g, which corresponds to its characteristic slender and small grain size, a trait often associated with faster cooking and distinct aroma (Rajeswari *et al*., 2019). Sivapu Kavuni, on the other hand, had the highest 1000-grain weight of 22.475 g, suggesting comparatively plumper grains similar to Mappillai Samba but with slightly higher mass, likely due to its denser endosperm and pigment accumulation in the bran (Karthikeyan *et al*., 2021). These differences in 1000-grain weight are important as they influence cooking quality, water absorption. (Balasubramanian & Reddy, 2018).

Alkali spreading value

With respect to gelatinization, the alkali spreading values revealed distinct differences among the varieties. Seeraga Samba (Fig 2.1) exhibited a low alkali spreading value, indicating a higher gelatinization temperature and hence a longer cooking time. Mappillai Samba(Fig 2.2) showed a high alkali spreading value, suggesting a lower gelatinization temperature and a shorter cooking duration. In contrast, Sivapu Kavuni(Fig 2.3) recorded a high alkali spreading value, denoting a lower gelatinization temperature and moderate cooking time. These observations are in agreement with earlier reports by Cuevas *et al*. (2010) and Tuano *et al*. (2018).

Mappilai Samba	Seeraga Samba	Sivapu Kavuni

Fig 3 Alkali spreading of rice varieties

Cooking properties

Length and breadth

- In the present study, the length and breadth wise expansion of the three traditional rice varieties after cooking varied considerably (Table 2). Seeraga Samba recorded a post-cooking grain length of 5.94 mm with a breadth of 2.28 mm, while Sivapu Kavuni showed a higher length expansion of 8.3mm with a breadth of 3.5mm. Mappilai Samba exhibited the highest length expansion of 5.65mm with a breadth of 1.82 mm, reflecting a distinct cooking profile. A linear model was developed to describe the mass of rough rice grain based on kernel length, with determination coefficients of 0.8202, 0.7852, and 0.8486 for Mappillai samba, Seeraga samba and Sivapu kavuni,respectively.

linear elongation ratio after cooking

When length and breadth were taken together as a ratio, Seeraga Samba and Mappillai Samba expressed favorable length-to-breadth (L/B) ratios, indicating slender grain quality after cooking. This trait is generally associated with consumer preference and market acceptability, as also highlighted by Pilaiyar (1988) and Hossain *et al*.,(2009).

Table: 1 Physical properties of selected rice varieties.

Characteristics / rice varieties	Seeraga samba	Mappilai samba	Sivapu kavuni
L (mm)	4.08	5.70	5.72
B (mm)	1.80	1.82	1.84
L/B	2.254	3.13	3.10
Moisture content (db%)	12	13	12.5
Alkali spreading value	High	Moderate	Low

Water absorption ratio

The water absorption ratio reflects the ability of rice grains to absorb water during cooking, influencing texture and swelling (Sowbhagya & Bhattacharya, 1979). In this study, Seeraga Samba recorded a ratio of 2.3 g, Mappillai Samba had 2.9 g, and Sivapu Kavuni showed the highest value of 3.5 g. Seeraga

Samba's lower value indicates moderate water uptake, resulting in firmer, less sticky grains. Mappillai Samba, with an intermediate ratio, exhibits moderate swelling and softness, while Sivapu Kavuni's higher ratio suggests greater water absorption, producing softer and more expanded grains. These differences are likely due to variations in amylose content, grain structure, and porosity, which influence cooking behavior and textural properties (Ramesh, Bhattacharya, & Mitchell, 2000; Mohan & Janarthanan, 2004).

Table: 2 Cooking properties of selected rice varieties.

Characteristics / rice varieties	Seeraga samba	Mappilai samba	Sivapu kavuni
L (mm)	5.94	5.65	8.3
B (mm)	2.28	1.82	3.5
L/B	2.61	3.10	2.37
Water absorption ratio	2.3	2.9	3.5

Conclusion

- The traditional rice varieties Mappilai Samba, Red Kavuni, and Seeraga Samba each have unique cooking and physical qualities that highlight their rich heritage and diversity. Mappilai Samba is known for its firm texture, high fiber content, and earthy aroma, making it a perfect choice for energy-boosting meals. Sivapu Kavuni, with its deep red color, is rich in anthocyanins and antioxidants, offering a slightly chewy texture and a pleasant nutty flavor. Seeraga Samba stands out for its small, fine grains, delicate fragrance, and excellent cooking quality, making it the preferred choice for biryani and festive dishes. Their physical traits—like kernel size, bulk density, and true density—play a key role in determining cooking time, water absorption, and final texture. Altogether, these traditional rice varieties not only enrich our culinary traditions but also promote better nutrition and help preserve India's valuable agricultural heritage. The findings highlighted the importance of understanding the physical properties of rice grains for various applications in the rice industry, including handling, processing, and grading

REFERENCES

1. Khush, G. S. (2005). What it will take to feed 5.0 billion rice consumers in 2030. *Plant molecular biology*, *59*(1), 1-6.
2. Sweeney, M., & McCouch, S. (2007). The complex history of the domestication of rice. *Annals of botany*, *100*(5), 951-957.
3. Balasubramanian, P., & Rani, R. (2017). Nutritional and medicinal values of traditional rice varieties. International Journal of Research Studies in Biosciences, 5(7), 6–14.
4. Sompong, R., Siebenhandl-Ehn, S., Linsberger-Martin, G., & Berghofer, E. (2011). Physicochemical and antioxidative properties of red and black rice varieties from Thailand, China and Sri Lanka. *Food chemistry*, *124*(1), 132-140.
5. Shao, Y., Xu, F., Sun, X., Bao, J., & Beta, T. (2018). Phenolic acids, anthocyanins, and antioxidant capacity in rice (Oryza sativa L.) grains at four stages of development after flowering. Food Chemistry, 143, 90–96

6. Bhattacharya, K. R., & Sowbhagya, C. M. (1971). An improved method of simple bulk-density determination of raw and parboiled rice. Cereal Chemistry, 48, 457–462.

7. Mohsenin, N.N. (1986). Physical Properties of Plant and Animal Materials. Gordon and Breach Science Publishers.

8. Rohilla, R. (2000). Alkali spreading value test and its relevance in rice quality. Journal of Food Science and Technology, 37(5), 511–515.

9. Azmi, N., *et al.* (2021). Determination of moisture content in grains: a comparison of oven-drying methods. Food Research, 5(3), 45–52.

10. Bett-Garber, K.L., Champagne, E.T., McClung, A.M., & Moldenhauer, K.A. (2007). Influence of physicochemical, morphological, and sensory properties on cooked rice texture. Cereal Chemistry, 84(6), 669–676.

11. Singh, V., *et al.* (2005). Cooking and eating characteristics of rice grain. Journal of Food Science and Technology, 42(5), 415–420.

12. Singh, R.K., Singh, U.S., & Khush, G.S. (2000). Aromatic rices. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.

13. Pilaiyar, P. (1988). Studies on cooking qualities of rice. Madras Agricultural Journal, 75(7-8), 325–329.

14. Hossain, M.S., Singh, A.K., Fasih-uz-Zaman. (2009). Cooking and eating characteristics of some newly released rice varieties. Bangladesh Journal of Agricultural Research, 34(4), 545–554.

15. Cuevas, R.P., Pede, V.O., McKinley, J., Velarde, O., & Demont, M. (2010). Rice grain quality and consumer preferences: A case study of two rural towns in the Philippines. Philippine Agricultural Scientist, 93(4), 432–440.

16. Tuano, P.M., Laborte, A.G., & Paris, T.R. (2018). Cooking quality traits of rice and consumer preferences in Southeast Asia. International Rice Research Notes, 43, 45–53.

17. Mohan, V. R., & Janarthanan, M. (2004). Nutritional and antinutritional evaluation of traditional rice varieties. Indian Journal of Traditional Knowledge, 3(4), 423–429

18. Ramesh, M., Bhattacharya, K. R., & Mitchell, J. R. (2000). Developments in understanding the basis of cooked-rice texture. Critical Reviews in Food Science and Nutrition, 40(6), 449–460.

19. Farahmandfar, R., Farahmandfar, E., & Ramezani, A. (2009). Physical properties of rough rice. *International Journal of Food Engineering*, *5*(5). https://doi.org/10.2202/1556-3758.1573

20. Muthayya, S., Sugimoto, J. D., Montgomery, S., & Maberly, G. F. (2014). An overview of global rice production, supply, trade, and consumption. Annals of the New York Academy of Sciences, 1324(1), 7–14.

21. Chowdhury, S., Bhattacharya, K. R., & Ali, S. Z. (2011). Physicochemical and textural characteristics of cooked rice from varying amylose content. Journal of Texture Studies, 42(4), 273–281.

22. Gujral, H. S., & Kumar, V. (2020). Physicochemical, textural, and sensory characteristics of traditional Indian rice varieties. Journal of Cereal Science, 93, 102955.

23. Pang, Y., Ali, J., Wang, X., Franje, N. J., Revilleza, J. E., Xu, J., & Li, Z. (2016). Relationship of apparent amylose content with cooked rice texture and starch fine structure in rice varieties from China and the Philippines. Food Chemistry, 212, 100–107.

24. Fofana, M., Futakuchi, K., Manful, J. T., & Chaudhary, R. C. (2011). Physicochemical and sensory properties of rice as affected by parboiling method. International Journal of Food Properties, 14(6), 1351–1367.

25. Deepa, G., Singh, V., & Naidu, K. A. (2010). Nutrient composition and physicochemical properties of Indian traditional rice varieties. Food Chemistry, 123(4), 813–819.

26. Sruthi, R., & Nithya, V. (2022). Comparative analysis of physical, chemical, and cooking properties of traditional pigmented rice varieties of Tamil Nadu. Indian Journal of Traditional Knowledge, 21(3), 504–512.

27. Rohit, K., & Bhosale, S. (2023). Characterization of traditional Indian rice varieties for physicochemical and cooking properties. Journal of Food Science and Technology, 60(5), 1562–1571.

28. Shittu, T. A. Olanivi, M. B. Ovekanmi, A. A. Okeleye, K. A. (2012). Physical and water absorption characteristics of some improved rice varieties. Food and Bioprocess Technology 5, 298- 309.