PHYSICAL AND FUNCTIONAL PROPERTIES OF TRADITIONAL RICE CULTIVARS (*ORYZA SATIVA* L. *INDICA*)

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ABSTRACT

The Rice cultivation is long and complicated. After the first cultivation of rice, there will be a spread of rice to all over the world and also been cultivated in different geogrpahies, such as in America. Since its spread, rice has become a global staple crop important to food security and food cultures around the world. The rice of *Oryza sativa L. indica* have resulted over around 40,000 varieties of rice cultivars. The rice as been considered as traditional, commercial and domestic rice. The characterization of twenty two staple rice cultivars consumed in India were evaluated for dimensional properties (Length, Breadth, and Thickness). Mathematical study have been carried out in twenty two rice cultivars, Arithmetic mean, Geometric mean, Equivalent diameter, Aspect ratio, Sphericity and Surface area and the results were analyzed by applying the Duncan Multiple Range test(DMRT) procedure using ANOVA. All these dimensions and analysis show that which type of rice has the finest quality.

Keywords: Rice cultivars, Traditional rice, Dimensions.

INTRODUCTION

Divergence in the rice grain quality represents its economic value and has also a fundamental role in popularity of traditional cuisine or intensifies significant candidate adoption from commercial varieties. Physical characteristics, cooking, sensory and engineering properties,textural and nutritional profiles comprise the major rice grain qualities. Each quality traits or characteristic traits would be valued by the preference of the consumers, which differs according to their traditional cooking habits and culture (Fitzgerald, McCouch, & Hall, 2009). Grain quality indicators such as kernel elongation and length/breadth ratio have essential characteristicsin the food industry and consumer preference. Genotypic or varietal differences among the rice varieties aids in increasing the costumers' satisfaction and admiration of the specific rice variety, and the knowledge familiarity of physical properties of grain materials is also convenient for designing suitable technologies for grain processing operations such as sorting, drying, heating, cooling, milling, and optimization associated with each specific variety (Mir, Bosco, & Sunooj, 2013).

Rice (*Oryza sativa* L.) occupies the prominent staple food and nutritious crop nourishes the one-quarter of global per capita dietary energy intake. Previous research works has been authenticating the physical and qualitative attributes of rice grain for different cultivars predominantly from South- East Asia, primary rice cropping area. However, substantially meager attention is given to rice grain quality research in other parts of the world, including Indian sub- continent, where rice has traditionally being considered as the most famous staple food after wheat with main cultural role in local Indian cuisines of different federal states. Local rice varieties are still cultivated by the farmers for their livelihood in this region (Hori, 2016; Mir et al., 2013; Tran et al., 2012). However, there is lack of scientific knowledge about their qualitative and sensory attributes. India, a typical country from South Asia, where rice plays

essential part in both farmer's food security and livelihood as well as in local traditional cuisine in Tamil Nadu, a federal state.

Globally, traditional rice varieties are cultivated, especially black rice commonly grown and consumed in Sri Lanka, Philippines, Thailand and India. However, China represents first position in the black rice cultivation (Ichikawa et al., 2001). Red rice varieties were widely cultivated in Indian states such as Kerala, Karnataka, Tamil Nadu, Bihar, Orissa, Bengal, Madhya Pradesh, and other North-eastern states within area having an unfavorable condition such as deep water, drought, sandy soils, salinity, and cold conditions. There are many rice varieties known as traditional or speciality or pigmented/colored rice varieties. Pigmentation of the rice varieties are due to the presence of anthocyanin pigments behind the husk on the outermost layer of the rice, which infuses a specific color such as red, black/purple, a nd brown color. In the earlier periods, the traditional rice varieties were cultivated for its nutritional and medicinal purpose. Even after higher grade of milling, a shade of red color remains in the outermost layer of the rice grains (Bhattacharjee, Singhal, & Kulkarni, 2002).

Red rice varieties are more nutritive among these colored traditional varieties with intact germ layer filled with anthocyanins and phenolics. Self-consumption of cultivated traditional rice varieties were followed in some regions of India like Kerala (Matte), Maharashtra (Patni), Kulu valley in Himachal Pradesh (Jatu, Matali) grows a varied range of red rice varieties. Due to the presence of anthocyanins, they have been used in the traditional medicine systems like siddha and Ayurveda. In the present study, 22 traditional rice varieties including few standard commercial varieties were selected to study the physicochemical, cooking, and engineering properties.

MATERIALS AND METHODS

Plant material

The dried rice kernels were collected from the traditional rice cultivating farmers in November, 2019 in and around Namakkal and Salem District, Tamil Nadu, India. In total, twentytwo different rice cultivars were bought, of which were four commercial cultivars (IR64, MDU- 6, ADT-39, Improved white ponni and Tirupathi Saram), and one was Basmati (other state rice variety) from North India (Table 1). Fifteen among them were traditional rice varieties. The samples were collected from different farmers, to sustain average sample quality of each variety (in average amount of 700 g).

Cultivar samples were cleaned from small particles (as stones and dried weeds) and kept in closed plastic bags in room temperature till the laboratory tests. Only good quality rice grains were used for the analysis, and each measurement was taken in required number of repetitions to ensure significant result.

Table 1. List of Rice Varieties used in the study

S.No.	Name of the Variety/Cultivar	Nature of Origin
1.	Karuthakar	Traditional
2.	Semmuli Samba	Traditional
3.	Chandikar	Traditional
4.	Karungkuruvai	Traditional
5.	Basmati	Other state
6.	Kudai vazhai	Traditional
7.	Thenkaipoo samba	Traditional
8.	Bodamalai Nel	Traditional
9.	Attur kichili	Traditional
10.	Tirupathi Saram	Traditional
11.	MDU-6	Commercial
12.	Vellai chitraikar	Traditional
13.	Kallurundaikar	Traditional
14.	60-am Kuruvai	Traditional

15.	IR64	Commercial
16.	Kuliyadichan	Traditional
17.	Thuyamallee	Traditional
18.	Improved White Ponni	Commercial
19.	Poonkar	Traditional
20.	ADT-39	Commercial
21.	Garudan Samba	Traditional
22.	Karuppu Kavuni	Traditional

Physical and Dimensional Properties

Length, width and thickness

The length L (mm), width W (mm), and thickness T (mm) of the rice kernels were determined by use of Vernier caliper with accuracy of 0.01 mm. Rice kernels were randomly selected, and each of their dimension was measured and recorded 20 times on each cultivar.

Arithmetic mean diameter

$$(\mathrm{Da}) = \frac{L + W + T}{3}$$

Geometric mean diameter

The geometric mean diameter (mm) was determined based on the measured dimensions of rice samples using equation given by Mpotokwane et al., (2008).

Geometric mean diameter (Dg) is equivalent to $(L \times W \times T)^{1/3}$

Equivalent diameter

Equivalent diameter *De* (mm) was determined using a following equation (Mohsenin, 1986):

$$D_e = \left(L \frac{(W+T)^2}{4} \right)^{\frac{1}{3}}$$

Aspect ratio

The aspect ratio *Ra* (−) was calculated using formula (Varnamkhasti et al., 2008):

$$R_2 = \frac{W}{L}$$

Sphericity

The sphericity of rice φ (−), was defined by the formula mentioned by Mohsenin (1986):

$$\varphi = \frac{(L \times W \times T)^{1/3}}{L}$$

Breadth and Surface area

For calculation of surface area S (mm^2) were used previously recorded variables length, width, and thickness. The formula for surface area was described by Mohsenin (1986) and Jain and Bal (1997) as the following:

where $B = (W \times T)^{1/2}$ (mm) is a function of width and thickness. Ratio between length andbreadth also calculated.

Volume

$$S = \frac{\pi \times B \times L^2}{2 \times L - B}$$

Volume of grain V (mm^3) was calculated by the formula mentioned by Jain and Bal (1997) as following:

$$V = \frac{1}{4} \times \left[(\pi/6) \times L \times (W \times T)^2\right]$$

Statistical analysis

All the experiments were carried out in triplicate and tabulated as Mean, standard Error (SE). The replications in each individual analysis were done 10 times for each cultivar. The Pearson's correlation coefficient was used to assess the interrelationship among various quality parameters. The results were analyzed by applying the Duncan Multiple Range test (DMRT) procedure using Analysis of Variance ANOVA. Difference between means was declared statistically significant at $p > 0.05$. Principal component analysis (PCA) was performed to classify the rice cultivars with different physicochemical and cooking characteristics by using SPSS 21.0 version.

RESULTS AND DISCUSSION

Univariate analysis

The traditional and commercial rice varieties have a broad variation range in the dimensional characters. Length, width, thickness, arithmetic mean diameter, geometric mean diameter, equivalent diameter, aspect ratio, sphericity, breadth, L/B ratio, surface area and sample volume showed the varying degree of polymorphism (Fig 1& 2). The longest varieties from traditional varieties was Bodamalai Nel with 6.48 mm (the longest from research sample), and shortest was Attur kichili with 5.24 mm. From the commercial varieties, the longest rice was Basmati with 7.85 mm and the shortest IR64 with 5.13 mm, which was also the shortest from the whole research sample (Table 2). Results show clear difference between traditional and commercial varieties (Tables 2, 3 & 4). From the analysis of measurement of width and thickness categories can be concluded, that chandikar rice variety, local to Tamil Nadu, has one of the largest physical dimensions from the research sample, while Thuyamallee owns one of the smallest dimensions in the research fragment. When measuring the physical properties of rice, dimensional properties of grains are the major features that need to be involved (Bhattacharya, 2011).

Dimensional measurements such as length, width, thickness, breadth, AMD, GMD and few more parameters of grains become the simple values for the researchers to start the basic grain research activities (Varnamkhasti et al., 2008). Grain dimension measurements are the basic values to determine its shape and further to calculate many dimensional properties. Smanalieva et al. (2015) measured length, width, and thickness at Ozgon rice variety, in different storage times. Our study was in agreement with previous research on dimensional properties; however, the long storage time gives the finest rice quality.

Table 2. Basic measurements for traditional and commercial rice varieties

S.No.	Name of the Variety/Cultivar	Length (mm)	Width (mm)	Thickness (mm)
1.	Karuthakar	5.64	2.82	1.90

2.	Semmuli Samba	5.39	2.65	1.30
3.	Chandikar	5.59	3.14	2.96
4.	karungkuruvai	5.53	2.82	1.79
5.	Basmati	7.85	1.90	1.15
6.	Kudai vazhai	5.94	2.84	1.80
7.	Thenkaipoo samba	5.92	2.16	1.27
8.	Bodamalai Nel	6.48	2.79	1.60
9.	Attur kichili	5.24	1.97	1.06
10	Tirupathi Saram	5.74	2.62	1.80
11	MDU-6	7.01	2.08	1.30
12	Vellai chitraikar	6.33	2.78	1.71
13	Kallurundaikar	5.46	2.51	1.31
14	60-am Kuruvai	5.66	2.68	1.50
15	IR64	6.90	1.94	.97
16	Kuliyadichan	5.87	2.67	1.50
17	Thuyamallee	5.47	2.02	1.04
18	Improved White Ponni	5.13	1.97	0.94
19	Poonkar	6.05	2.81	2.04
20	ADT-39	5.43	2.24	1.26
21	Garudan Samba	5.95	2.65	1.80
22	Karuppu Kavuni	6.44	2.61	1.50
	Mean	5.95	2.48	1.52
	Standard Error	0.14	0.07	0.09

The average length of traditional rice recorded in the present study was 5.95 mm (±0.21) which is lower compared to average results of Kyrgyz varieties 6.76 mm (±0.36) in previous study (Nadvornikova et al., 2018). Similar traditional rice varieties from India showed distinct dimensional variations, which might be due to the environmental and genotype interaction. The mean dimensions values for width and thickness of grains were 2.48 mm (±0.07) and 1.52 mm (±0.07), respectively. These results were significantly similar to earlier report in Kyrgyz rice varieties, in which width ranged upto 2.90 mm (±0.17). Fofana et al. (2011) and Díaz et al. (2015) also showed a wider spectrum of dimension measurements of different varieties.

Table 3. Mean diameters and breadth measurements for rice varieties

S.No.	Name of the Variety/Cultivar	AMD	GMD	Breadth	L/B ratio	De
1.	Karuthakar	3.45	3.11	2.31	2.44	3.16
2.	Semmuli Samba	3.11	2.65	1.86	2.90	2.76
3.	Chandikar	3.89	3.73	3.05	1.83	3.73
4.	Karungkuruvai	3.38	3.03	2.24	2.46	3.08
5.	Basmati	3.63	2.58	1.48	5.31	2.63
6.	Kudai vazhai	3.53	3.12	2.26	2.62	3.18
7.	Thenkaipoo samba	3.12	2.54	1.66	3.57	2.60
8.	Bodamalai Nel	3.62	3.07	2.11	3.06	3.15
9.	Attur kichili	2.76	2.22	1.44	3.63	2.29
10.	Tirupathi Saram	3.39	3.00	2.17	2.64	3.04
11.	MDU-6	3.47	2.67	1.65	4.26	2.72
12.	Vellai chitraikar	3.61	3.11	2.18	2.90	3.17
13.	Kallurundaikar	3.10	2.62	1.81	3.01	2.71
14.	60-am Kuruvai	3.28	2.83	2.01	2.82	2.91
15.	IR64	3.27	2.35	1.37	5.02	2.44
16.	Kuliyadichan	3.35	2.87	2.00	2.93	2.95
17.	Thuyamallee	2.85	2.26	1.45	3.76	2.34
18.	Improved White Ponni	2.68	2.12	1.36	3.76	2.22
19.	Poonkar	3.63	3.26	2.39	2.53	3.29
20.	ADT-39	2.98	2.49	1.68	3.23	2.56
21.	Garudan Samba	3.47	3.05	2.18	2.73	3.09
22.	Karuppu Kavuni	3.52	2.93	1.98	3.26	3.00
	Mean	3.32	2.80	1.93	3.21	2.86
	Standard Error	0.06	0.08	0.08	0.17	0.07

AMD-Arithmetic mean diameter, GMD-Geometric mean diameter, L/B-length/Breadth ratio

The arithmetic mean diameter varied from 2.76 to 3.89 mm, whereas geometric diameter ranged from 2.22 to 3.73 mm in the traditional cultivars group. Attur kichili and Chandikar occupied the minimum and maximum range for both AMD and GMD, respectively. In the commercial varieties were recorded values from 2.68 mm (White Ponni) to 3.63 mm for Basmati. Similarly, the geometric mean diameter for commercial varieties differs from 2.12 mm for white ponni to 3.00 mm in Tirupati Saram. Likewise, the result of equivalent diameter corresponds with previous mean diameter conclusions, which the largest equivalent diameter belong to the traditional rice group. Equivalent diameter is another significant parameter to establish grain characteristics. Our measurements was in agreement with Mir et al. (2013) with Indian rice varieties recorded results ranging from 3.60 to 3.79 mm and Varnamkhasti et al., (2008) measured 3.30 mm and 3.40 mm on Iranian rice cultivars for diameter values.

Aspect ratio and sphericity are the two grain measurements, where the traditional rice varieties showed the maximum values than the commercial rice. However, the length varies in both rice groups; the aspect ratio depends upon the width, which seems to be higher in the traditional rice groups. As similar to the length, Chandik ar exhibited highest aspect ratio and sphericity among the research samples. However, the lowest measurements found in both traditional and commercial rice varieties. Both findings are quite similar to the results of this study. Surface area values varied from 12.66 mm² (for White Ponni) to 36.75 mm² for Chandikar. The cultivars with the lowest surface area are frequently the improved commercial varieties - Improved white ponni, ADT-39, IR-64 and Basmati. The cultivars with highest surface area are the traditional varieties represented in the research sample. It is important to mention quite values of standard deviation.

When compared to the present study, two authors indicated higher values for the surface area from 34.32 mm² till 43.78 mm² for paddy rice from India (Mir et al., 2013), 39.63 mm² till 49.69 mm² on the new Nigerian rice (Shittu et al., 2012). However, we had similar results with

Table 4. Dimensional and functional characteristics of rice varieties

S.No.	Name of the Variety/Cultivar	Aspect Ratio	Sphericity	Surface Area	Sample Volume
1.	Karuthakar	.50	.55	25.79	9.95
2.	Semmuli Samba	.49	.49	18.98	5.88
3.	Chandikar	.56	.67	36.75	18.66
4.	Karungkuruvai	.51	.55	24.44	9.14
5.	Basmati	.24	.33	20.11	4.95
6.	Kudai vazhai	.48	.53	26.05	9.82
7.	Thenkaipoo samba	.37	.43	17.94	4.96
8.	Bodamalai Nel	.43	.47	25.70	9.06
9.	Attur kichili	.37	.42	13.80	3.32
10.	Tirupathi Saram	.46	.52	24.12	8.72
11.	MDU-6	.30	.38	20.52	5.63
12.	Vellai chitraikar	.44	.49	26.22	9.54
13.	Kallurundaikar	.46	.48	18.64	5.63
14.	60-am Kuruvai	.47	.50	21.67	7.24
15.	IR64	.28	.34	16.50	3.78
16.	Kuliyadichan	.46	.49	22.24	7.42

17	Thuyamallee	.37	.41	14.39	3.48
18	Improved White Ponni	.38	.41	12.66	2.87
19	Poonkar	.46	.54	28.35	11.32
20	ADT-39	.41	.46	16.99	4.77
21	Garudan Samba	.44	.51	24.96	9.08
22	Karuppu Kavuni	.40	.45	23.61	7.78
	Mean	0.42	0.47	21.83	7.4
	Standard Error	0.01	0.01	1.18	0.75

the previous reports given on Indian paddy long- grain varieties with surface area of 13.99 mm² (Thakur & Gupta, 2006), and from 25.62 mm² to 38.46 mm² on rice which was studied by (Varnamkhasti et al., 2008).

Table 5. Descriptive statistics for the rice varieties

Variables	**Minimum**	**Maximum**	**Range**	**Mean**		**Variance**
Length	5.13	7.85	2.72	5.95	0.14	0.43
Width	1.90	3.14	1.24	2.48	0.07	0.14
Thickness	0.94	2.96	2.02	1.52	0.09	0.20
AMD	2.68	3.89	1.21	3.32	0.06	0.098
GMD	2.12	3.73	1.61	2.80	0.08	0.153
De	2.22	3.73	1.51	2.86	0.07	0.139
Aspect Ratio	0.24	0.56	0.32	0.42	0.01	0.006
Sphericity	0.33	0.67	0.34	0.47	0.01	0.006
Breadth	1.36	3.05	1.68	1.93	0.08	0.171
L/B ratio	1.83	5.31	3.48	3.21	0.17	0.697
Surface Area	12.66	36.75	24.09	21.83	1.18	31.05
Sample Volume	2.87	18.66	15.79	7.4	0.75	12.50

Surface area and thickness of grains are essential dimensions for diffusion water during cooking process along with cooking time (Juliano, 1993; Mohapatra and Bal, 2006) (Table 5). The span of results in sphericity measurement went from 0.41 till 0.67 (0.49–0.56 for traditional varieties and 0.33–0.52 for commercial ones) and aspect ratio measurements ranged from 0.37 till 0.55 (traditional varieties) followed by commercial varieties from 0.24 to 0.46.

SUMMARY AND CONCLUSION

Twenty two staple rice cultivars consumed in India were evaluated for dimensional properties in this study. The dimensions of investigated grains correspond to 5.13 – 7.85 mm for length, 1.90–3.14 mm for width, and 0.94–2.96 for thickness. Mean diameter such as arithmetic, geometric and Equivalent diameter was in range of 2.68 –

3.89, 2.12-3.73 and 2.22 – 3.73, respectively. The sphericity analysis values varied from 0.33 to 0.67, aspect ratio from 0.24 to 0.56, volume of the grain was measured in range from 2.87 to 18.66 mm^3, surface area values were 12.66–36.75 mm^2. The clustering of traditional and commercial rice cultivars by PCA explained that the first PC with Eigenvalue of 9.427 showed the total variance about 78.55%. The largest positive loadings of variab les were arithmetic mean diameter and length/breadth ratio. The second PC with Eigenvalue of 2.312 confirmed an additional 19.26% of the total variance. Optimal cooking time showed that imported varieties needed lower interval for full grain cooking compared to the commercial varieties. It was found that traditional rice varieties staying more firm after cooking as compared to imported varieties and therefore more suitable for the local traditional dish such as porridge.

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