Evaluation of aromatic and non-aromatic rice 
(Oryza sativa L.) genotypes for physio-chemical, cooking and nutritive quality traits in Konkan Region

VJ Gimhavanekar, MM Burondkar, SG Bhave, VV Dalvi, BS Thorat, SS Chavan, SG Mahadik and AK Shinde

DOI: https://doi.org/10.22271/chemi.2020.v8.i5t.10498

Abstract
The present study evaluated physio-chemical, cooking and nutritive qualities of 58 aromatic and non-aromatic rice genotypes. These genotypes differed significantly for hullying percentage, milling percentage, grain length, grain width, volume expansion ratio, water uptake ratio (WUR), elongation ratio, alkaline spreading value (ASV), gelatinization temperature (GT), amylose content, carbohydrate content and protein content. The hullying and milling percentage was ranged from 70.60% (Dhanaprasad)-78.35 (HMT Sona) & 60.80 (Girga)-67.88% (Karjat-2), respectively. HMT Sona (78.35%) and Karjat-2 (67.88%) was recorded significantly maximum hullying and milling percentage, respectively. Among all, Patnijira (4.23), SKL-7 (4.77) and Parag (4.12) as fine grain genotypes for L/B ratio; Phule radha (1.52), Kundlika (1.47) and Girga (1.42) for elongation ratio; Elaichi (6.63), Mamala (6.50), Patnijira (6.50), Pusasugandha (6.38) and Kundlika (6.38) for intermediate alkali value and Phule Malav (24.94%) for maximum amylose content. Among all, Kundlika (7.62%) and Basmati-107 (77.83%) was recorded maximum protein and carbohydrate content, respectively. The characteristics of the various grain types make them suitable for different food preparations and meet the preferences of majority of consumers.

Keywords: Aromatic rice, physio-chemical, qualities, cooking, nutritive, hullying and milling

Introduction
Aromatic rice (Oryza sativa L.), is known for its characteristic fragrance when cooked. This constitutes a small but special group of rice, which is considered best in quality. Aromatic varieties fetch higher price in rice market than the non-aromatic ones. Cultivation of aromatic rice has been gaining popularity in India over the recent years because of its huge demand both for internal consumption and export (Dutta et al., 2002) [10]. It is also preferred by some consumers despite their price and yield. Hence efforts are now being made to explore the possibility of cultivating the scented rice in non-traditional area to prove its potential. The slogan of International year (2004) of rice “Rice is life” is the most appropriate for India as this crop play a vital role in our national food security and means of livelihood for millions of rural households. In India export rice around 10.3 million metric tonnes. Total global consumption of milled rice amounted to approximately 477.77 million metric tonnes in 2016-17. China consumed around 146 million metric tonnes of milled rice per year, and was by far the world leading rice consumer in the year. In comparison U. S. consumed some 3.85 million metric tonnes (Anonymous, 2017) [13].

Rice grain quality is determined by its physical and physicochemical properties. Physical properties include kernel size, shape, milling recovery, degree of milling and grain appearance (Cruz and Khush, 2000) [9]. Physicochemical properties of rice are determined based on amylose content, alkali spreading value and gelatinization temperature (Rohilla et al., 2000) [22]. In rice, eating and cooking qualities are mainly controlled by the physicochemical properties which greatly influence the consumer's choice (Rohilla et al., 2000 and Sujatha et al., 2004) [22, 23]. The consumers accept rice that possesses good cooking and eating qualities. The texture of the cooked grain influences the palatability and thus the acceptability to consumers (Kang et al., 2006) [14].
Grain size and shape are usually the first criteria of rice quality that breeders consider when developing new varieties for commercial production. The longer grain types are usually associated with higher amylose content and dry fluffy cooked rice, while the typical short grain types are moist and sticky when cooked. The physical dimensions of rice kernels are of vital interest in marketing and grading, in developing new varieties and in processing. Volume expansion over cooking is another quality parameter which influences the edible volume which is the final output after cooking (Rebeira et al., 2014) [21]. The gel consistency determines the softness of cooked rice. Therefore, eating and cooking quality can be considered as a vital intrinsic quality component of rice grains that have to be focused in future rice breeding programmes to meet market demands at both local and international level. In the present experiment main objective is to evaluate the aromatic and non-aromatic rice genotypes for quality parameters under konkan region.

Material and Methods

The experiment was carried out at Regional Agricultural Research Station, Karjat, Dist. Raigad (MS) during Kharif 2017 and 2018. It is situated at 18°91’67” North latitude and 73°33’ East longitude with an altitude of 194 meters (636 ft) above the mean sea level with warm and humid conditions throughout the year. The mean annual precipitation is 3500 mm, which is generally received during the month from June to November at the location. Fifty eight aromatic and non-aromatic rice genotypes were used and cultured in a Randomized Block Design (RBD) with two replications. All the samples were brought to laboratory, transferred in to cotton bags and stored at room temperature for analysis. Estimation of physical and chemical quality characteristics was at RARS, Karjat and Dr. BSKKV, Dapoli. The analysis was by following methods

1. Milling quality

A. Hulling percentage: The hulling % is calculated by the formula i.e.,

\[ \text{Hulling} \% = \frac{\text{Wt. of dehusked kernel}}{\text{Wt. of paddy}} \times 100 \]

Where, Wt. of paddy = 100 gm

B. Milling percentage: The milling % is calculated by the formula i.e.,

\[ \text{Milling} \% = \frac{\text{Wt. of polished kernel}}{\text{Wt. of paddy}} \times 100 \]

Where, Wt. of paddy = 100 gm

2. Quality character

A. Grain length and width (mm): Ten threshed grains were taken randomly and average length was recorded by using digital Vernier Caliper.

B. L/B ratio: The length/breadth ratio was obtained by dividing the length of a single grain by the corresponding breadth to determine the size and shape.

C. Water Uptake Ratio: Water uptake ratio of the milled rice samples were estimated by the method suggested by Bhattacharya and Sowbhagya (1971) [9].

D. Volume Expansion Ratio: Volume expansion ratio of the milled rice samples were estimated by the method suggested by Juliano (1965) [13].

E. Elongation Ratio: Elongation ratio of the milled rice samples were estimated by the method suggested by Azeez and Shafi (1966) [5].

F. Alkali Spreading Value: Alkali spreading value of the milled rice samples were estimated by the method suggested by Little (1958) [18].

G. Estimation of Amylose: Amylose contents of the milled rice samples were estimated by the method suggested by Juliano (1971) [14] involving the spectrophotometer.

3. Nutritive Quality

A. Carbohydrate content: Carbohydrate estimated by anthrone anthrone. It is first hydrolysed into simple sugars using dilute hydrochloric acid. In acidic medium glucose is dehydrated to hydroxymethyl furfural. This compound forms with anthrone a green coloured product with an absorption maximum at 630 nm.

B. Protein content: The protein content in dry seed was estimated by multiplying total nitrogen content into the factor 5.95. The plant sample were analyzed for percent nitrogen content by micro kjeldahl distillation method (Jackson, 1967) [12].

Result and Discussion

1. Milling Quality Traits

Data on hulling and milling quality for aromatic and non-aromatic rice genotypes are presented in table 1. In the present investigation, significantly maximum hulling percentage was recorded in HMT Sona (78.35%) which was at par with Velchi (77.48%), Karjat-2 (77.48%) and Phule Maval (77.43%) over other rice genotypes. The minimum hulling percentage was recorded in Dhanaprasad (70.60%). Significantly maximum milling percentage was recorded in Karjat-2 (67.88%) which was at par with ACK-5 (67.75%), HMT Sona (67.75%) and Pusa Sugandha-5 (67.55%) over other rice genotypes. The minimum milling percentage was recorded in Girga (60.80%). Varietal difference for milling quality was also reported by Verma et al (2013) [28], Verma et al (2015), Saravanan Ponnapan et al. (2017) [25] and Subhalakshmi et al. (2018) [26].

| S. No. | Genotypes    | Hulling (%) | Milling (%) |
|-------|--------------|-------------|-------------|
| 1     | Phule Maval (G1) | 77.43       | 67.38       |
| 2     | Phuleradha (G2)  | 72.38       | 64.50       |
| 3     | SKL-7 (G3)      | 73.33       | 63.77       |
| 4     | Terrana (G4)    | 74.58       | 66.25       |
| 5     | Parar (G5)      | 71.06       | 64.40       |
| 6     | ACK-5 (G6)      | 77.41       | 67.75       |
| 7     | HMT Sona (G7)   | 78.35       | 67.75       |
| 8     | Kasturi (G8)    | 71.45       | 62.63       |
| 9     | Paras Sona (G9) | 71.86       | 62.88       |

Table 1: Physiological evaluation of aromatic and non-aromatic rice genotypes for milling quality of rice
| S. No | Genotypes            | Grain length (mm) | Grain width (mm) | L/B ratio | ER   | WUR   | VER   | ASV | AC (%) |
|-------|----------------------|-------------------|------------------|-----------|------|-------|-------|-----|--------|
| 1     | Phule Maval (G1)     | 6.66              | 3.43             | 1.94      | 1.06 | 337.50| 5.11  | 4.88| 24.94  |
| 2     | Phuleradha (G2)      | 5.42              | 1.69             | 3.22      | 1.52 | 356.25| 4.42  | 4.63| 23.28  |
| 3     | SKL-7 (G3)           | 6.33              | 1.33             | 4.77      | 1.20 | 206.25| 2.95  | 6.13| 19.43  |
| 4     | Terana (G4)          | 6.68              | 1.82             | 3.66      | 1.05 | 350.00| 4.54  | 6.25| 22.57  |
| 5     | Parag (G5)           | 6.64              | 1.61             | 4.12      | 1.04 | 275.00| 4.85  | 6.25| 22.81  |
| 6     | ACK-5 (G6)           | 5.29              | 2.73             | 1.94      | 1.27 | 243.75| 4.28  | 4.88| 22.91  |
| 7     | HMT Sona (G7)        | 6.65              | 1.90             | 3.51      | 1.03 | 143.75| 5.11  | 1.75| 23.03  |
| 8     | Kasturi (G8)         | 6.81              | 1.96             | 3.48      | 1.05 | 225.00| 5.39  | 2.13| 23.23  |
| 9     | Paras Sona (G9)      | 5.88              | 2.22             | 2.66      | 1.17 | 250.00| 4.69  | 1.75| 22.52  |

2. Quality Characters

Data on grain length, grain width, L/B ratio, elongation ratio, water uptake ratio, volume expansion ratio and alkali spreading value for aromatic and non-aromatic rice genotypes are presented in Table 2.
Significant differences were observed within aromatic and non-aromatic rice genotypes. The rice genotypes under study was represented all classes from short (<5.5 mm) to extra-long (>7.5 mm). Aromatic rice genotypes had grain length between 4.14-8.29 mm, grain width between 1.33-3.43 mm and grain length-width ratio 1.91-4.77. Significantly maximum grain length was recorded in Pussasugandha-2 (8.29 mm) which was at par with Mamla (8.25 mm) over other rice genotypes and minimum grain length was recorded in Girga (4.14 mm). The significantly maximum grain breadth was recorded in Phule Maval (3.43 mm) and minimum grain breadth was recorded in SYE-7 (1.33 mm). The significantly maximum L/B ratio was recorded in SYE-7 (4.77 mm) which was at par with Sugandha (4.59) over other rice genotypes and minimum L/B ratio was recorded in Ambemohar (1.91 mm). L/B ratio indicates the shape and size of rice kernel which are important quality characters of rice (Abdul Baset Mia et al., 2012) [1].

**B. Elongation Ratio**

Elongation ratio was recorded significantly maximum in aromatic rice genotypes, Phuleradha (1.52) which was at par with Kundlika (1.47), Girga (1.42) and minimum elongation ration was recorded in HMT-Sona (1.03). Varietal difference

| L/B ratio | Length Breadth ratio | ER: Elongation ratio | VER: Volume expansion ratio | ASV: Alkali spreading value | WUR: Water uptake ratio | AC: Amylose content |
|-----------|----------------------|----------------------|-----------------------------|-----------------------------|-------------------------|---------------------|
| 0.07      | 0.24                 | 0.31                 | 0.10                        | 35.09                       | 0.53                    | 0.76                |

**A. Grain length, breadth and L/B ratio**

Significant differences were observed within aromatic and non-aromatic rice genotypes. The rice genotypes under study was represented all classes from short (<5.5 mm) to extra-long (>7.5 mm). Aromatic rice genotypes had grain length between 4.14-8.29 mm, grain width between 1.33-3.43 mm and grain length-width ratio 1.91-4.77. Significantly maximum grain length was recorded in Pussasugandha-2 (8.29 mm) which was at par with Mamla (8.25 mm) over other rice genotypes and minimum grain length was recorded in Girga (4.14 mm). The significantly maximum grain breadth was recorded in Phule Maval (3.43 mm) and minimum grain breadth was recorded in SYE-7 (1.33 mm). The significantly maximum L/B ratio was recorded in SYE-7 (4.77 mm) which was at par with Sugandha (4.59) over other rice genotypes and minimum L/B ratio was recorded in Ambemohar (1.91 mm). L/B ratio indicates the shape and size of rice kernel which are important quality characters of rice (Abdul Baset Mia et al., 2012) [1].
for elongation ratio was also reported by Sanjiva et al. (1952) [24].

C. Water Uptake Ratio
Water uptake ratio was recorded significantly maximum in aromatic rice genotypes, Phuleradha (356.25) which was at par with Terana (350.00), Belgaum Basmati (346.25), Pawana (346.25), Sugandha (343.75), Phule Maval (337.50) and RDN-Scented (331.25) over other rice genotypes. The minimum water uptake ratio was recorded in HMT Sona (143.75). Varietal difference for elongation ratio was also reported by Verma et al. (2015).

D. Volume Expansion Ratio
The significantly maximum volume expansion ratio was recorded in aromatic rice genotypes, Kasturi (5.39) which was at par with Kundlika (5.23), PKV-HMT (5.14), Bishnubhog (5.12), HMT-Sona (5.11) and Phule Maval (5.11) over other rice genotypes. The minimum volume expansion ratio was recorded in SYE-7 (2.95). Similar result reported by Hossain et al. (2009) [113], Verma et al. (2015) and Subhalakshami et al. (2018) [26].

E. Alkali spreading value and gelatinization temperature
Evaluated different rice genotypes for alkali spreading value and found the ranges from 1.75 to 6.63. The significantly maximum alkali spreading values was recorded in aromatic rice genotypes, Elaichi (6.63) which was at par with Mamala (6.50), Patnijira (6.50), Pusasugandha (6.38) and Kundlika (6.38) over other rice genotypes. The minimum alkali spreading value was recorded in Paras Sona (1.75). The rice genotypes under present study exhibited all three ranges of GT- high (>74°C), intermediate (70-74°C) and low (<55-69°C).

F. Amylose Content
The significant differences were observed within the aromatic and non-aromatic rice genotypes. The maximum amylose content was recorded in aromatic rice genotypes, Phule Maval (24.94 %) and minimum amylose content was recorded in SYE-7 (19.43 %). The varietal difference for amylose content was also reported by Sagar et al. (1988) and Asaduzzaman et al. (2013) [23, 4].

3. Nutritive Quality Traits
Data on carbohydrate content and protein content for aromatic and non-aromatic rice genotypes are presented in table 3.

Table 3: Physiological evaluation of aromatic and non-aromatic rice genotypes for nutritive quality of rice

| S. No. | Genotypes       | Carbohydrate (%) | Protein (%)  |
|-------|-----------------|------------------|--------------|
| 1     | Phule Maval (G1) | 74.37            | 6.60         |
| 2     | Phuleradha (G2)  | 75.41            | 5.45         |
| 3     | SKL-7(G3)        | 73.36            | 6.89         |
| 4     | Terana (G4)      | 74.56            | 7.60         |
| 5     | Parag (G5)       | 73.23            | 7.22         |
| 6     | ACK-5 (G6)       | 73.30            | 6.05         |
| 7     | HMT Sona (G7)    | 73.86            | 7.58         |
| 8     | Kasturi (G8)     | 73.32            | 5.07         |
| 9     | Paras Sona (G9)  | 75.21            | 6.54         |
| 10    | Lolak (G10)      | 74.17            | 6.14         |
| 11    | Tulsi-75-14 (G11)| 75.36            | 4.70         |
| 12    | Basmati-63 (G12) | 72.42            | 6.85         |
| 13    | Pusa Sugandha-5 (G13) | 73.10    | 7.58         |
| 14    | Basmati-107 (G14) | 77.83            | 7.40         |
| 15    | Basmati-386 (G15) | 75.22            | 5.65         |
| 16    | Super Basmati (G16) | 75.28            | 6.89         |
| 17    | Antarvel (G17)   | 73.30            | 6.87         |
| 18    | Kala Jeera (G18) | 73.34            | 6.16         |
| 19    | Dhanaprasad (G19) | 72.51            | 7.22         |
| 20    | Bishnubhog (G20) | 72.82            | 7.60         |
| 21    | Shrabannasi (G21) | 73.86            | 7.49         |
| 22    | Pusasugandha (G22) | 72.88            | 6.82         |
| 23    | Kala Krishna (G23) | 74.30            | 6.16         |
| 24    | Belgaum Basmati (G24) | 75.53            | 7.58         |
| 25    | RDN-Scented (G25) | 73.69            | 6.28         |
| 26    | Mamla (G26)      | 74.77            | 5.51         |
| 27    | Ghanalal regional (G27) | 72.90            | 6.41         |
| 28    | Pakistan basmati (G28) | 73.46            | 7.46         |
| 29    | Pusa basmati (G29) | 72.94            | 7.26         |
| 30    | Kate chinoor(G30) | 74.36            | 6.14         |
| 31    | RDN-local (G31)  | 74.59            | 5.88         |
| 32    | Lala (G32)       | 73.45            | 7.01         |
| 33    | Durgabhog (G33)  | 72.89            | 7.55         |
| 34    | Velchi (G34)     | 74.56            | 6.85         |
| 35    | PKV-khamang (G35) | 75.11            | 6.41         |
| 36    | PKV-HMT (G36)    | 74.65            | 7.12         |
| 37    | PKV-ganesh (G37) | 72.89            | 6.53         |
| 38    | PKV-Makrand (G38) | 73.36            | 7.60         |
| 39    | Ambika (G39)     | 72.35            | 7.47         |
A. Carbohydrate Content
The significant differences were observed within aromatic and non-aromatic rice genotypes for grain carbohydrate content. The significantly maximum carbohydrate content was recorded in aromatic rice genotypes, Basmati-107 (77.83 %) which was at par with Basmati-388 (77.50 %) over other rice genotypes. The minimum carbohydrate content was recorded in Karjat-3 (72.23%). Varietal difference for carbohydrate content was also reported by Juliano (1972) [15], Asaduzzaman et al. (2013) [14] and Chingakham et al. (2016) [8].

B. Protein Content
The significantly maximum protein content was recorded in aromatic rice genotypes, Kundlika (7.62%) which was at par with Terana (7.60%), Bishnubhog (7.60%), PKV-Makrand (7.60%) and HMT-Sona (7.58%) over other rice genotypes. The minimum protein content was recorded in Tulsi 75-14 (4.70%). Varietal difference for protein content was also reported by Pederson and Eggum (1983), Ahmed et al (1998), Buresova et al. (2010) and Abdul Baset Mia et al. (2012) [20, 2, 7, 1].

Conclusion
In conclusion, study showed that varietal differences were evident in physio-chemical, cooking and nutritive traits of aromatic and non-aromatic rice. Among aromatic & non-aromatic rice genotypes, HMT Sona and Karjat-2 was recorded significantly maximum hulling and milling percentage, respectively. Among aromatic & non-aromatic rice genotypes, Patnijira, SYE-7 and Parag as fine grain genotypes for L/B ratio; Phule radha, Kundlika and Girga for elongation ratio; Elaichi, Mamala, Patnijira, Pusasugandha and Kundlika for intermediate alkali value and Phule Maval for maximum amylose content. Among aromatic & non-aromatic rice genotypes, Kundlika and Basmati-107 was recorded maximum protein and carbohydrate content, respectively. The gathered information can be useful towards improvement of respective traits in quality rice breeding programme.

| Range          | Varietal          | Protein Content | Carbohydrate Content |
|----------------|-------------------|-----------------|----------------------|
| 72.23-77.83    | S.E±              | 0.30            | 0.06                 |
| C.D at 5%      |                   | 0.85            | 0.16                 |

A. Carbohydrate Content

B. Protein Content

References
1. Abdul Baset Mia, Mira Rani Das, Muhammad Kamruzzaman, Nur Muhammad Talukder. Biochemical Traits and Physico-Chemical Attributes of Aromatic-Fine Rice in Relation to Yield Potential. American Journal of Plant Sciences. 2012; 3:1788-1795.
2. Ahmed SA, Barua I, Das D. Chemical composition of scented rice. Oryza. 1998; 35:167-169.
3. Anonymous. Directorate of Economics and Statistics. Department of Agriculture and Cooperation. Ministry of Agriculture, Government of India, 2017.
4. Asaduzzaman M, Haque ME, Rahman J, Hasan SK, Ali MA, Akter MS et al. Comparisons of physiochemical, total phenol, flavanoid content and functional properties in six cultivars of aromatic rice in Bangladesh. African Journal of Food Science. 2013; 7(8):198-203.
5. Azeem MA, Shafiq M. Quality in rice: Tech Bull 13, 50. Department of Agriculture, West Pakistan, 1966.
6. Bhattacharya KR, Sowbhagya CM. Water uptake by rice during cooking. Cereal Sci. Today. 1971; 16:420-24.
7. Buresova, Sedlickova, Famera O, Lipavsky J. Effect of growing conditions on starch and protein content in triticale grain and amylose content in starch. Plant Soil Environ. 2010; 56(3):99-104.
8. Chingakham Sima Chanu, Yanagi NB, Math KK. Nutritional and functional evaluation of black rice genotypes. J. Farm Sci. 2016; 29(1):61-64.
9. Cruz DN, Khush GS. Rice grain quality evaluation procedures. In: Aromatic rice. Singh, R. K, Singh, U. S., Khush, G. S. (ed): 6-28. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi, India, 2000.
10. Dutta RK, Mia MAB, Khanam S. Plant architecture and growth characteristics of fine grain and aromatic rice and their relation with grain yield. Research and Applied Technology, 2002.
11. Hossain MF, Bhuiya MSU, Ahmed M, Mian MH. Effect of harvesting time on the milling and physiochemical properties of aromatic rice. J. Agril. Sci. 2009; 42(20):91-96.
12. Jackson ML. Soil Chemical Analysis, Prentice Hall, India Private Limited, New Delhi, 1967, 183-192.
13. Juliano BO, Onate LU, DelMundo AM. Relation of starch composition, protein content and gelatinization temperature to cooking and eating qualities of milled rice. Food Technol. 1965; 19:1006-11.
14. Juliano BO. A simplified assay for milled-rice amylase. Cereal Sci. Today. 1971; 16:334-40.
15. Juliano BO. Physicochemical properties of starch and protein in relation to grain quality and nutritional value of rice. In: IRRI Rice Breeding. IRRI, 1972, 389-405.
16. Juliano BO. Rice starch: production, properties and uses. In: Whistler R L, BeMiller J N and Paschall E F (ed) Starch Chem Technol. Academic Press Inc, New York, 1984.
17. Kang HJ, Hwang IK, Kim KS, Choi HC. Comparison of the physicochemical properties and ultrastructure of japonica and indica rice grains. J Agric Food Chem. 2006; 54:4833-38.
18. Little RR, Hilder GB, Dawson EH. Differential effect of dilute alkali on 25 varieties of milled white rice. Cereal Chem. 1958; 35:111-26.
19. Parikh M, Rastogi NK, Sarawgi AK. Variability in grain quality traits of aromatic rice (Oryza sativa L.). Bangladesh J. Agril. 2012; 37(4):551-558.
20. Pederson B, Eggum BO. The influence of milling on the nutritive value of flour from cereal grains. Rice Plant Foods Hum Nutr. 1983; 33:267-78.
21. Rebeira SP, Wickramasinghe HAM, Samarasinghe WLG. Diversity of grain quality characteristics of traditional rice (Oryza sativa L.) varieties in Sri Lanka. Trop Agric. Res. 2014; 25:470-78.
22. Rohilla R, Singh VP, Singh US, Singh RK, Khush GS. Crop husbandry and environmental factors affecting aroma and other quality traits. In: Singh, R. K., Singh, U. S. and Khush, G. S. (ed) Aromatic rices., 201-216. Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi, India, 2000.
23. Sagar MA, Ahsraf M, Akmal MA. Grain quality characteristics of Pakistani commercial rice varieties. Pak J Agric Res. 1988; 9:431-36.
24. Sanjiva RB, Vasudeva MAR, Subrahmany RS. The amylose and the amyllopectin contents of rice and their influence on the cooking quality of the cereal. Proc Indian Acad Sci. 1952; 36:70-80.
25. Saravan Panppannap, Arun Thangavel, Omprakash Sahu. Milling and Physical Characteristics of Pigmented Rice Varieties. Journal of Food and Nutrition Sciences. 2017; 5(6):236-241.
26. Subhalakshmi Shijagurumayum GA, Shantibala Devi, Brajakishore Singh CH. Grain quality evaluation of some aromatic rice varieties of Manipur, India. Res. on Crops. 2018; 19(2):169-181.
27. Sujatha SJ, Ahmed R, Bhat PR. Physicochemical properties and cooking qualities of two varieties of raw and parboiled rice cultivated in the coastal region of Dakshina Kannada. Indian J Food Chem. 2004; 86:211-16.
28. Verma DK, Mohan M, Asthir B. Physicochemical and cooking characteristics of some promising basmati genotypes. Asian J Food Agro-Ind. 2013; 6:94-99.