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Physico-chemical characterization of *indigenous* and *exotic* rice germplasm accessions for quality traits

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Abstract
Improvement of rice grain quality is a major concern in rice breeding programs to increase the farmer income as well as meet out the consumer preference and market demand. The major aim of present investigation is to evaluate the 207 *Indigenous* and *Exotic* collection rice accessions for Physico-chemical characterization. Physico-chemical analysis relies on the rice chemical composition and sensory test like cooking quality, alkali spreading value, gel consistency and physical properties of cooked rice. The huge amounts of variability are found in present investigating materials. Analysis of variance was conducted to determine differences between check varieties with traits and block effect was found significant for quality traits *i.e.,* kernel breadth after cooking, and kernel length breadth ratio after cooking was found significant and traits hulling percentage, head rice recovery, decorticated grain length, decorticated grain breadth, decorticated grain length breadth ratio, kernel length after cooking, gel consistency found non-significance. These results indicate that, blocking was not important for these traits. The some of the accessions were identified for important traits in which the accessions *viz.,* EC 3545400, EC 457050, IC 466813 etc. were found for high hulling percentage, high milling percentage and head rice recovery accessions *i.e.,* IC 577038 was identified, accessions *viz.,* IC 377527, IC 462507, IC 377173 etc. having high decorticated grain length, accessions *i.e.,* IC 89155, IC 282408, IC 310431 were identified for intermediate type of alkali spreading value and accessions *viz.,* IC 114652, IC 332998, IC 377014 etc. having medium gel consistency. The accessions *i.e.,* IC300202, IC343505, IC376473, IC376492, IC382577, IC418446, IC463907, IC463961, IC466813, IC467041, IC467085, IC579014 having high aroma. These results show that Physico-chemical characterization using the available test procedures can be effectively utilized in analysis of diversity in rice germplasm as well as quality rice improvement programme.

Keywords: Physico-chemical, quality, variability, *Indigenous* and *Exotic* rice and germplasm

Introduction
Rice (*Oryza sativa* L.) is the staple food of almost half of the world population. The cultivation of rice is about 114 developing countries and regularly consumed at household level as primary source of diet [25]. The preference for taste, colour, and stickiness of rice varieties varies among different cultures. It contributes about 40–80% of total calories intake [19]. The major challenges of rice development in many rice producing areas of the world is maintaining rice grain quality to meet the diverse interest groups in the rice sub-sector. The parameters of good cooking and eating quality is a right stepping in the right direction for selection of donors to rice quality improvement [7].
Cooking qualities in rice is associated with chemical properties *i.e.* gel consistency and alkali spreading value. Physical quality is determined by the grain dimension, hulling, milling and head rice recovery while starch gelatinization temperature constitutes the chemical quality of rice [29]. The efficient breeding program involves the steps like creating genetic variability, practicing selection and utilization of genotypes to evolve promising lines for quality traits. In crop improvement programme, to increase the productivity breeder needs to maintain a pool of diverse desirable donor parents [9].
Information of nature and amount of genetic variability helps for obtaining high heterotic crosses and transgressive segregants for quality improvement in rice programme. Keeping in view the above perspectives, the specific objectives of this work is, therefore, to evaluate the variability and Physico-chemical characterization of rice germplasm for quality parameters aiming to improve quality rice without compromising the yield.

Materials and Methods

In this study, a total of 207 *Indigenous collection* (IC) and *Exotic* collection (EC) rice germplasm accessions were evaluated in augmented design [8] with seven checks *i.e*., Annada, Jaya, Pusa Basmati 1, Swarna, NDR97, IR64 and Karma Mahsuri during *Kharif*-2014 under irrigated condition at Research-cum-Instructional farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh. The checks were replicated and each plot consisted of two rows of 2.90 m length and spacing between rows X row is 40 cm.

The experimental materials were received from NBPGR, New Delhi. Data for the following 13 Physico-chemical and quality traits *viz.*, Hulling percentage, milling percentage, head rice recovery (%), decorticated grain length (mm), decorticated grain breadth (mm), decorticated grain length breadth ratio, kernel shape, kernel length after cooking (mm), kernel breadth after cooking (mm), kernel length breadth ratio after cooking, aroma, alkali spreading value and gel consistency (mm) were recorded from all germplasm accession and replicated checks at suitable growth stage of rice germplasm. The recorded observations were analyzed by using XLSTAT 2014 software. The methodology of sample collection and their preparation for estimation of Physico-chemical and cooking quality parameters is as given below:

i) Estimation of physical properties

Properly cleaned 100 g paddy sample (13% moisture) were used for dehusking the rice samples by using Satake laboratory sheller, miller and grader. Depending on the size of grains, the polished grains were passed through rice grader having different (mm) grooves. The whole grains were separated from the broken grains in order to quantify the head rice recovery. Full grains and ¾ size grains were weighed and considered as head rice. Ten milled grains were taken randomly from each accession and average grain length breadth was recorded by Grain Shape Tester or Dial micrometer (mm) for the estimation of decorticate grain length, decorticated grain breadth, decorticated grain length breadth ratio and kernel shape and size according to [24]. The hulling percentage, milling percentage, head rice recovery and decorticated grain length breadth ratio were estimated with the help of following formulae is as given below:

Hulling percent = Weight of dehusked kernel / Weight of paddy X 100

Milling percent = Weight of polished kernel / Weight of paddy X 100

Milling per cent = Weight of whole polished kernel / Weight of paddy X 100

Decorticated grain length breadth ratio = Length milled grains / Breadth milled grains

ii) Estimation of Chemical properties

Alkali spreading values were determined as per procedure described by [12]. Disintegration was determined by placing 10 polished rice grains in a Petri plate containing 10 ml of freshly prepared 1.7% (w/v) KOH solution. Seeds were arranged with the provision of space between the grains for spreading.

The Petri plates were then covered and placed in a 30^0C incubator for 23 hours. This test was performed in triplicates for accuracy and validity of the test results. The degree of disintegration of each of the grains was rated visually according to [22]. The various range of alkali spreading value and their classification are presented in Figure: 1 and Table: 1 respectively.

Gel Consistency was determined as per procedure described by [4]. Approximately 100 mg rice flour from each rice genotype was weighed in triplicates and. placed in a 13 mm × 100 mm test tube. A total volume of 0.026 ml of 95% ethanol containing 0.025% thymol blue was added to each tube and mixed so as to prevent clumping of the rice flour. The mixture was vortexed gently, and then 2 ml of 0.2 N KOH was added and vortexed again. Each tube was covered with glass marbles to prevent steam loss and reflux of the samples and placed over a boiling water bath at 95^0C for 8 minutes. They were then 0-2 ºC for 20 after that cultures tubes are removed from ice bath are laid horizontally for 1 hour over ruled or graph paper and the blue gel length was measured from the bottom of the tube to the end of the gel in millimeters. This test was performed in triplicates to ensure accuracy and validity of the results. The Classification of gel consistency is presented in order to Figure: 2 and Table: 2.

iii) Estimation of cooking quality and Aroma

Cooking Procedure: Milled rice sample (5 g) was taken in a test tube with excess water, soaked for 10 minutes and placed in boiling water bath for 15 minutes. Test tubes were removed and cooled. Then cooked rice was transferred into petri plate with filter paper. Ten cooked whole grains were selected and put on a graph paper mounted with glass frame. The data for kernel length after cooking (mm), kernel breadth after cooking (mm), kernel length breadth ratio after cooking were recorded.

Grain aroma was determined at post harvest stage. Milled rice sample (5 g) were taken in a test tube (200 mm X 35 mm) with 15 ml of water, soaked for 10 minutes and placed in boiling water bath for 15 minutes. Then cooked rice was transferred into petri plate. After cooling, it was kept in the refrigerator for 20 minutes. Then the petri plates were opened and the contents were smelled. The samples possessing the scent, as one could easily feel, produce a sharp and readily recognizable aroma and score as below:

HS: Highly scented, MS = Medium scented, LS: Low scented, NS = Non-scented.

Results and Discussion

i) Analysis of variance

In this study, variance was estimated based on mean sum of square. The differences between check varieties were highly significant for the entire traits and block effect was found significant for quality traits *i.e.*, kernel breadth after cooking, and kernel length breadth ratio after cooking was found significant and traits hulling percentage, head rice recovery, decorticated grain length, decorticated grain breadth, decorticated grain length breadth ratio, kernel length after cooking, gel consistency found non-significance (Table: 3). These results indicate that, blocking was not important for these traits. The results are support with the findings of [14].

ii) Characterization variability analysis of *Indigenous collection* (IC) and *Exotic collection* (EC) of rice accessions for quality traits

The characterization of land races, in terms of rice quality, is essential to identify the donors for effective utilization of germplasm for rice quality improvement programme. A wide range of genetic variability has been reported for quality traits in the past, but still there exists untapped genetic variability in germplasm which is importance in selecting the potential parents so as to get maximum heterosis and superior recombinants with respect to quality components. The significant amount of genetic variation were observed in present investigation for quality traits among the rice accessions and evaluated as per [24 & 22].

The various ranges of alkalis spreading value and gel consistency is depicted in Figure 1 and 2 respectively. Frequency sharing for the quality characters showed huge variability among the evaluated rice accessions and are presented in Figure 3. The descriptive statistics were estimated for 207 *Indigenous collection* (IC) and *Exotic collection* (IC) rice accessions for quality traits are presented in Table 4.

Hulling percentage were estimated among the accessions, the accession EC 3545400 noted high hulling percentage 75.87 followed by EC 497050 (75.86), IC 466813(75.74), IC 45110 (75.73) and IC 545551 (75.71) etc. and minimum hulling percentage was recorded in IC 578985 (69.13) with a grand mean of 73.91. Among the checks variety, check Jaya (75.14) having highest hulling percentage. The high hulling percentage of rice is desirable in term of milling quality, because hulling percentage is highly associated with milling percentage. The similar type of finding has been reported by [23].

The milling percentages were estimated, to determine the milling characteristics of different rice accessions. In this study, milling percentage ranges from 60.71% (IC 451110) to 70.88 % (IC 467349) with a grand mean of 65.80%. The accessions *viz.,* IC577038 (70.87), IC 36930 (69.64), IC 377168 (69.2), IC 335860(68.65) IC 381834 (68.55) IC 376922 (68.07) and IC 381834 (68.5) were identified for high milling percentage comparing with check IR 64 having 64.83% milling percentage. Milling is an important step in processing of rice because grains behaviors during milling largely determine the market value of grain. The main aim of milling is to get edible, white rice kernel that is sufficiently milled and free of impurities [26].

The high magnitudes of variation were observed for this trait *i.e.,* head rice recovery. The maximum and minimum head rice recovery was recorded in IC 370818 (68%) and IC 262977 (54.92 %) respectively with a grand mean of 61.69%. The accessions *i.e.,* IC369303 (66.88), IC376584 (63.12), IC459645 (66.41) and IC577038 (66.6) comparably better than check NDR 97 (61.21). Head rice recovery is the most important parameter for obtaining the whole and head rice [16].

Decorticated grain length and breadth (mm) were also sowed enormous variation among the accessions and ranged from short (<8.5 mm) to long (10.6-12.5 mm) decorticated grain length. Most of the accessions (94%) were found short type decorticated grain length while, 5% and 1% accessions were recorded under medium and long type decorticated grain length respectively. The maximum decorticated grain length was found in IC377527 (9.8 mm) and minimum 5.0 mm in IC 459712 with the grand mean of 7.10 mm. For this trait, the check Pusa Basmati 1 (9.3) was found highest grain length followed by IR 64 (9.2).

The accessions *i.e.,* IC377527 (9.8), IC462507 (9.56), IC377173 (9.42), IC377258 (9.34) and IC450841 (9.31) were found superior over the checks. While, the accessions *viz.,* IC299924 (7.95), EC182372 (7.92), IC369301 (7.84), IC376653 (7.7), IC377168 (7.64), IC580716 (7.33) and IC578028 (7.31) found superior from check variety Karma Mahsuri (7.22) and NDR-97(7.21).

Whereas, decorticated grain breadth range from narrow (< 2.00 mm) to broad (>2.5 mm). The 12% accessions comes under narrow breadth (<2.0 mm), 73% accessions were found medium breadth (2.0-2.5 mm) and 15% accessions were observed under broad (>2.5 mm) decorticated grain breadth. The maximum grain breadth was recorded in IC 86495 (2.26 mm) and minimum breadth in IC 337598 (1.49 mm) with a grand mean of 2.88 mm.

The highest value for this trait was noted in the check variety Jaya (2.45) followed by Annada (2.37), Jaya (2.45) and Swarna (2.3) respectively. In comparison form these check variety, accessions *i.e.,* IC86495 (2.88), IC406404 (2.80), IC578985 (2.74), IC337148 (2.73), IC383441 (2.72), IC310431 (2.65), IC545518 (2.64), IC89155 (2.61) and IC447325 (2.60) were identified. While, for this trait, check variety Pusa Basmati 1(1.7) and IR 64 (1.9) showed lowest decorticated grain breadth and among the rice accessions *i.e.,* IC337598 (1.49), IC343505 (1.53), IC343515 (1.56), IC382577 (1.60), IC579014 (1.60) and IC579023 (1.66) having lowest decorticated grain breadth.

The maximum decorticated grain length breadth ratio was found in check variety Pusa basmati 1 (5.47 mm) followed by IC 382577 (5.44 mm), check variety IR 64 (4.84 mm) and IC 337598 (4.62 mm) IC377147 (4.4), IC377258 (4.34), IC462507 (4.31), IC466511 (4.56) and IC579023 (4.36). Whereas, minimum length breadth ratio of decorticated grain recorded in IC 337608 and IC 376492 and 376492 (2.0) respectively with a grand mean of 3.19. The current findings for the traits *i.e.,* decorticated grain length, decorticated grain breadth and decorticated grain length breadth ratio are confirmed with the finding of [27 & 15]. However, the kernel shape of accessions also showed wide variation and classified into four categories *viz*., slender (55%), medium (44%), bold (1%) and non of the accessions comes under round grain shape. The accessions namely IC89096, IC89156, IC252268, IC256614, IC256649, IC260917, IC262964, IC262967 etc. falls under slender category, however accessions *i.e.,* IC332639, IC332672, IC335860, IC336076, IC337148, IC337555, IC343538, IC346813, IC369303 etc. came under medium shape and only three accession *viz.,* IC86495, IC337608, IC376492 were identified under bold category. Kernel shape and length breadth ratio are important features and showed huge variation during assessing grain quality of rice. The findings of present investigation are similar with result of [18]. Grain size and shape have direct effect on yields of head rice however milling recovery depends on grain shape and appearance, which has directly affect the percentage of hulling, milling and head rice recovery thus the hulling, milling and head rice recovery has estimated and showed high amount of variation. Alkali spreading value and gelatinization temperature (GT) are inversely proportional to each other. A variety with low alkali spreading value has high GT. Gelatinization temperature and cooking time of milled rice is positively interconnected [10, 1 & 2].

Rices with high GT take longer time to cook than low GT types. In present investigation, alkali spreading value showed wide variation and grouped into four classes *viz*., low (22%), low-intermediate (18%), intermediate (27%) and high (33%). The various range of alkali spreading value of rice germplasm is depicted in Figure: 1. In current investigation accessions *viz.,* IC89155, IC145447, IC282408, IC310431, IC319524, IC332672, IC337608, IC340690, IC352794, IC356448, IC370818, IC376515, IC376535, IC376584, IC376646, IC377014, IC377147, IC377168 and IC377258 etc. were identified and having intermediate alkali spreading value while check varieties Pusa Basmati 1 and Jaya were also found intermediate type of alkali spreading value.

Gelatinization temperature (GT) based on alkali spreading score showed intermediate GT (70-74 ºC) in the majority of the rice varieties. The present investigation supported with several researchers [17, 11 & 30].

Gel consistency is the important starch property which affects the cooking and eating characteristics. The gel consistency test is based on the consistency of the rice paste and differentiates among verities with high amylose content. Varieties with soft gel consistency as preferred as the rice cooked would be tender. In present examination gel consistency showed wide variation and fall into three categories *i.e.*, hard (16%), medium (9%) and soft (75%). The gel consistency ranged from 29 mm to 99 mm in germplasm accessions and depicted in Figure: 2. The accessions *i.e.*, IC114652, IC331148, IC332998, IC334323, IC376646, IC376653, IC376674, IC377014, IC381827, IC381834, IC381981, IC383441, IC449994, IC450723, IC450917, were identified with medium gel consistencyf. However, check variety IR 64 were found hard gel consistency [3]. Similar classification of rice into three GC groups has been reported by [29] in non waxy rice varieties.

The traits aroma plays important role in its consumer acceptability and it draw a premium price in certain specialty markets. Prominent variability was recorded in grain for the trait of aroma. As per DUS procedure aroma is categorized in four categories *i.e.*, highly scented (HS), medium scented (MS), low scented (LS) and non scented (NS).

Among the accessions, 84% accessions come under non aromatic group, 6% highly scented and a 10% accession comes under medium scented group. The accessions *i.e.*, IC300202, IC343505, IC376473, IC376492, IC382577, IC418446, IC463907, IC463961, IC466813, IC467041, IC467085, IC579014 and check variety Pusa Basmati-1 were identified for high aroma. The similar kind of findings has been reported by [28 & 21].

Conspicuous variability was found in kernel length, kernel breadth and kernel length breadth ratio after cooking. The maximum kernel length after cooking was recorded in check Pusa Basmati 1 (13.80 mm) and minimum was recorded in IC 545518 (6.80 mm) with grand mean of 8.83 mm. The maximum and minimum kernel breadth after cooking were recorded in IC 376968 (4.20 mm) and IC 449585 (2.50 mm) respectively with grand mean of 3.16 mm. However, the maximum kernel length breadth ratio after cooking was found in check Pusa basmati 1 (5.31) followed by 4.13 mm in IC 382577 and minimum in IC 376492 and IC 449805 (2.09 mm) with a grand mean of 2.80 mm. The result supported with findings of [13, 15 & 6].

The quality desired would vary from one geographical region to the other and depends on consumer preference. For example in *japonica* rice eating countries, low amylose and short grain is preferred while in *indica* rice consuming countries, long grain with intermediate amylose and alkali spreading value, soft gel consistency and high volume expansion of cooked rice is preferred [5]. These results allied with [7&27] the current findings who characterized of quality traits for various Physico-chemical traits of rice accessions. Thus, characterization of quality traits is an important requirement to evaluate quality as well as various Physico-chemicals traits among the rice accessions. It creates the basis to ensure successful deployment of the crop by both farmers and breeders community, otherwise unevaluated germplasm remain mere curiosities to the breeding programmes.

Conclusion

From this study, it can be concluded that the classification showed considerable variation based their physical and chemical properties. Usually, most of the rice improvement progarmme concentrated on high yield. In current decades as human living conditions are being gradually enhanced, people demand for high quality rice is continuously on increase, which entailed in incorporation of preferred grain quality features as the most important objective next to enhancement in yield and also quality characteristics increase the total economic value of rice. Consequently, improving rice grain quality has been a major concern in rice breeding programs to increase the farmer income as well as meet out the consumer preference and market demand.

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Table 1: Classification of Alkali spreading value (ASV)

Classification	Alkali Spreading Value (ASV)	GT
1-2	Low	High (74^0)
3	Low, intermediate	High, Intermediate
4-5	Intermediate	Intermediate (70^0C- 74^0C)
6-7	High	Low (>70^0C)

Table 2: Classification of Gel consistency (GC)

Category	Description
a) 26 – 40 mm	Hard gel consistency
b) 41 – 60 mm	Medium gel consistency
c) 61 – 100 mm	Soft gel consistency

Table 3: Analysis of variance for various quality traits of rice accessions

S. No	Source of Variation	Mean Sum of Squares		
		Block	Check	Error
	Degree of Freedom	3	6	18
1	Hulling percentage	0.199	14.069**	0.969
2	Milling percentage	0.036	8.151**	1.176
3	Head rice recovery (%)	0.651	10.847**	0.976
4	Decorticated grain length (mm)	0.004	3.426**	0.004
5	Decorticated grain breadth (mm)	0.001	0.177**	0.007
6	Decorticated grain length breadth ratio	0.002	2.170**	0.04
7	Kernel length after cooking (mm)	0.005	12.514**	0.002
8	Kernel breadth after cooking (mm)	0.002*	0.319**	0.004
9	Kernel length breadth ratio after cooking	0.012**	2.741**	0.003
10	Gel consistency (mm)	1.286	3104.238**	1.286

Note: * and **Significant at 5% and 1% level of probability

Table 4: Descriptive statistics for various quality traits of rice accessions

S. No	Traits	Mean	Range		Standard Error	Standard deviation	Coefficient of variation
			Minimum	Maximum			
1	Hulling percentage	73.91	69.13	75.87	0.09	1.31	1.77
2	Milling percentage	65.80	60.71	70.88	0.21	2.98	4.53
3	Head rice recovery percentage	61.69	54.92	68.00	0.23	3.26	5.28
4	Decorticated grain length (mm)	7.10	5.00	9.80	0.06	0.83	11.69
5	Decorticated grain breadth (mm)	2.26	1.49	2.88	0.02	0.24	10.62
6	Decorticated grain length breadth ratio	3.19	2.00	5.47	0.04	0.52	16.35
7	Kernel length after cooking (mm)	8.83	6.80	13.8	0.08	1.10	12.46
8	Kernel breadth after cooking (mm)	3.16	2.50	4.20	0.02	0.27	8.54
9	Kernel length breadth ratio after cooking	2.80	2.09	5.31	0.03	0.37	13.21
10	Gel consistency (mm)	74.35	29.00	98.00	1.54	22.12	29.75

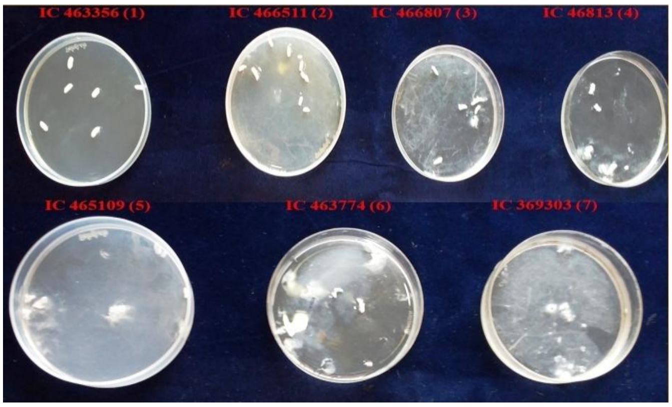


Fig 1: Various range of alkali spreading value of germplasm

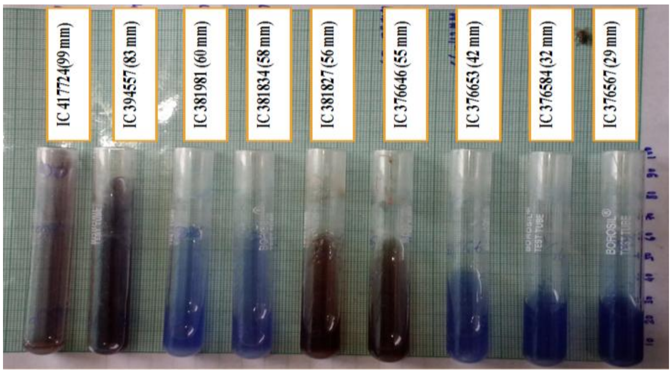
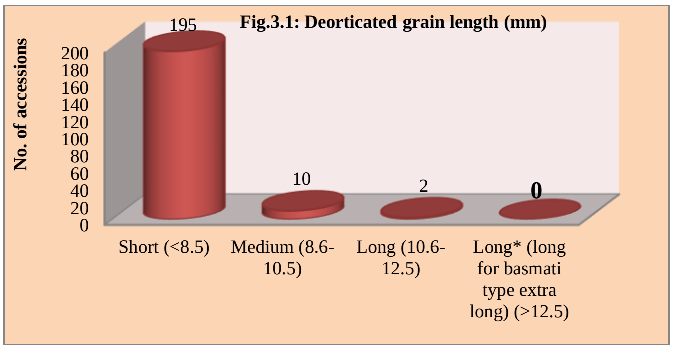
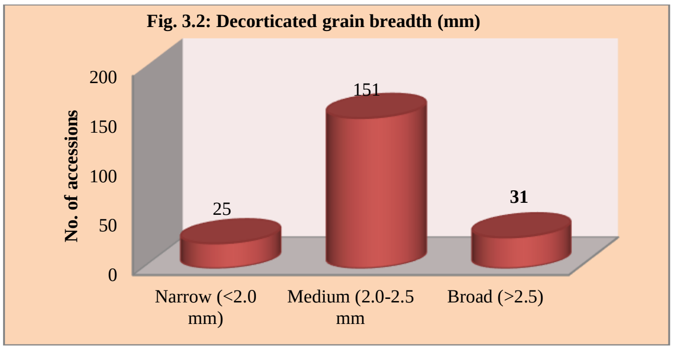
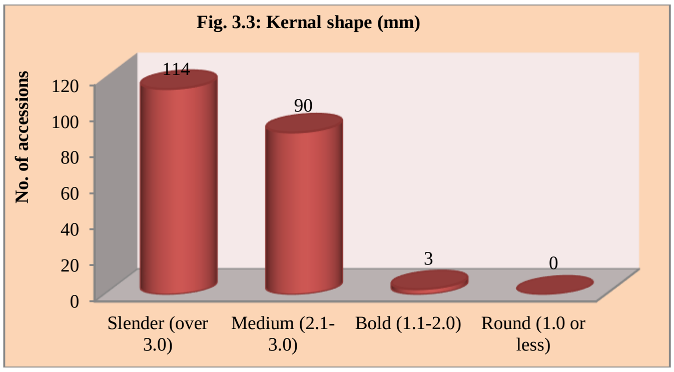
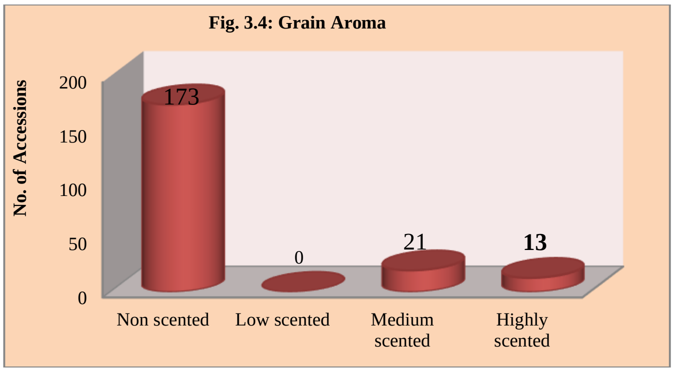


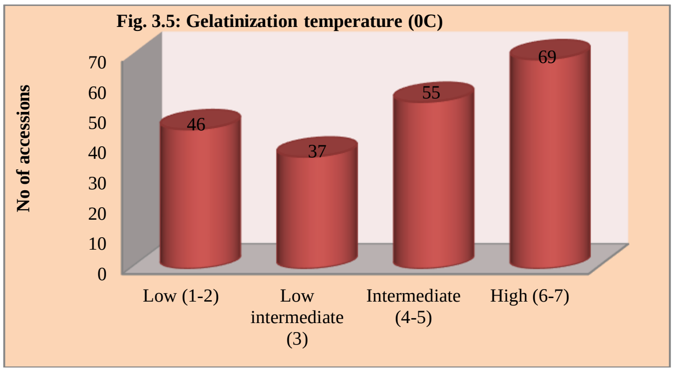
Fig 2: Ranges of gel consistency of germplasm accessions











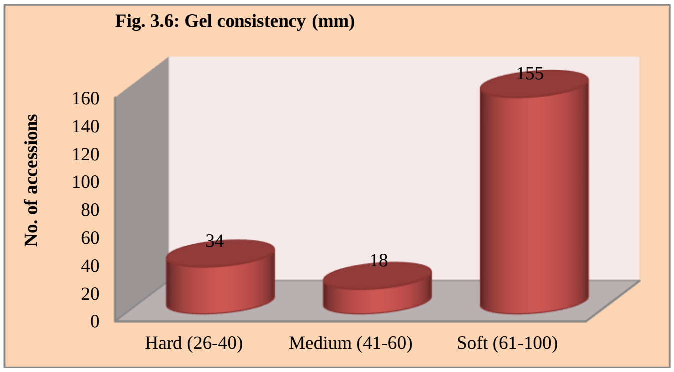


Fig 3: Frequency distribution of different descriptors used in quality characterization of rice.

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