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Research Article

ASSESSMENT OF PHYSICO-CHEMICAL PROPERTIES AND COOKING QUALITY OF RICE GERMPLASM CULTIVATED IN HIMACHAL PRADESH

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Abstract: Next to yield, grain quality is the most important factor considered by plant breeders. Although the demand for rice is likely to increase, the rice breeding stations and institutions had tried to improve indigenous rice for yield parameters along with cooking qualities. In the present study, we performed experiment to record the physicochemical and cooking properties of landraces cultivated in Aus season. We assessed the physico-chemical and cooking quality characteristics in selected land races grown in foot hills of Himalayan region (31.1048 °N; 77.1734 °E) mainly Himachal Pradesh. The main objective was to analyze the various quality aspects in terms of physiochemical and cooking quality of selected germplasm. Significant variation ($P<0.05$) was detected among the 20 rice varieties for all the traits evaluated. Among the 11 landraces, Saaldhan has the highest kernel width (2.98 mm), Hulling recovery (83.24%), milling recovery (82.58%), milled kernel length (2.73 mm) and water uptake ratio (4.15%), while as, Karad had lowest hulling recovery (70.88%), milled kernel length (4.21 mm), cooking grain width (3.41 mm). Amylose content (23.24-29.24) showed non-significant differences between the varieties, Head rice recovery was below 60% in the all the varieties.

Keywords: Amylose Content, Physicochemical characteristics, Cooking parameters, Traditional rice cultivars and Landraces

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Introduction

Rice (*Oryza spp*.) is one of the ancient cultivable grains of the world and is consumed by more than half of the global population as staple food [1]. It plays an important role in global food security particularly in fulfilling the calorie requirement of Asian and African countries [2]. Rice production has to increase 40% by 2030 [3] to meet the expected consumption requirement of populace, which has to be produced from shrinking land, limiting water [4] with the additional issue of climate change. To meet the challenge, high yielding, more fertilizer responsive and disease pest resistant varieties have to be developed. The main constraint for which is to maintain the grain and cooking quality while breeding for improved rice cultivars. The grain quality of any crop in general and rice in particular is very important for it to be accepted by the people for cultivation. Grain quality is determined by its physical properties like kernel size and shape, milling recovery, degree of milling, grain appearance and physicochemical properties such as amylose content (AC), gelatinization temperature (GT) and gel consistency (GC). Cooking and eating qualities are governed by these physical and physicochemical properties in case of rice. Tang and co-workers (1989) reported highly significant and negative correlation between AC and GC and between AC and GT, but a significant positive correlation between AC and grain elongation (GE). Among different quality traits, aroma and elongation after cooking are considered most important and lengthwise elongation upon cooking without increase in girth is considered most desirable in high quality rice. Size, shape and other physio-chemical including cooking characters are important for judging the rice grain quality. Despite of having economic value and popularity all over the world, there is little information [5] on the physical, cooking, and chemical properties of aromatic rice cultivars, their antioxidant properties are not well documented, either. Therefore, the present study was undertaken to determine the physical and chemical cooking properties of land races of Himachal Pradesh. Grain appearance including size, shape, and colour is the first thing that consumers look for during purchase. This characteristic influences to consumer preference which varies greatly from region to region [6]. Cooking and eating properties of milled rice play an important role in consumer preference particularly cooked rice texture, aroma and flavor. Rice composition and/or structure especially that of the starch, which is the major component, have a high correlation with cooking and eating properties rather than with physical characteristics [7]. The rice grain length, width and weight mainly determine the physical quality of rice grain. The classification of rice quality is based on the length of grain, *i.e*., short, medium and long grain. Grain shape is an important agronomic trait in cereal crops because it is directly or indirectly related to quality and quantity of grain products [8-10]. Moreover, grain size and shape are the first quality characteristics considered in developing new varieties. The length to breadth ratio ranging from 2.5 to 3.0 is widely acceptable and the grain length > 6 mm is more preferred [11]. The size and shape of the rice grain preferred by the people may vary from region to region. Some prefer short grains like in upper Himalayan region; some prefer medium grains like South Asian region and most commonly people like long slender grains in Indian sub-continent and in international market [12]. Thus, components of appearance traits are one of the first criteria for rice quality breeders in release and commercial production of varieties [13]. The ratio of length to width is also an important aspect to determine the shape of the variety [14] whereas; grain weight gives the information about the size and density of the grain. The density of different rice grains effect the cooking quality. The rice produced in different parts of India varies significantly in composition and cooking quality.

Genetic and environmental factors are mainly responsible for variation in composition and cooking quality of rice [15]. Consumer preference regarding cooking attributes of rice grains may vary from region to region. Japanese like sticky rice [16], while Italians consume short grain variety, which releases starch during cooking making a creamy and smooth risotto, Americans prefer a semi milled long grain rice or even brown rice, whereas Asian dominates spicy and scented Basmati/Jasmine rice and the people of Indian sub-continent prefer a well milled white rice [17]. Looking at the importance of the grain quality in rice, the present study was carried out to assess the rice grain quality including physical and physiochemical parameters in selected land races grown in foot hills of Himalayan region (31.1048 °N; 77.1734 °E) mainly Himachal Pradesh.

Materials and method

The present study was carried out at Department of Seed Science and Technology, CSKHPKV. Palampur. HP, India. Eleven germplasm lines of rice collected from different regions of Himachal Pradesh ware used for the study (Table.1). The laboratory experiment was conducted for physiochemical parameters. Varieties of paddy were manually cleaned and dehulled using a lab scale dehulling machine and did not undergo polishing. Dehulled grains were cleaned and used for the study. All the estimations were carried out in triplicates.

Table-1 Rice germplasm and their source

SN	Name	Source		Source/Pedigree
1	Chinudhan	Jandrangal	Landraces	Villege-Jandrangal
2	Jhinidhan	Timber	do	Pritam Chand. Dadh-Timber
3	Saaldhan	Bir	do	Bachtan Singh Villege-Bir
4	Sailadhan	Keor	do	Surjadevi. Villege-Keor
5	Kaludhan	Pangal	do	Pratap Singh-Pangal
6	Kalijhini-1	Jadrangal	do	Villege-Jadrangal
7	Kalijhini-2	Indragal	do	Shyam Lal-Indragal
8	Ramjawandhan	Nagarota	do	Bagawan –Nagarota
9	Sukara	Bhatiyala	do	Bhatiyat- Chamba
10	Chohartu	Rohru	do	Rohru, Shimla
11	Karad	Dadryada	do	Chamba

Physiochemical quality characters

Various physical and cooking parameters studied viz. seed size, shape, grain dimension, Length/Breadth Ratio, hulling and milling characters, the gelatinization temperature (GT), Water uptake ratio (WUR), Solid Loss in Gruel (SLG), Elongation ratio (ER), Cooked kernel length (CKL) and width (CKW), Amylose content (AC), Gel consistency (GC) Gelatinisation temperature (GT) using standardized methods. The method of analyzing each parameter is outlined below.

1. Grain length (mm): Ten grains (with husk) taken randomly and were arranged linearly average length was recorded in millimetre.
2. Grain breadth (mm): Ten grains (with husk) taken randomly and were arranged horizontally average breadth was recorded in millimetre.
3. Grain lengths: breadth (L/B) ratio: This was calculated by the following formula:

$$Paddy\ L/B\ ratio = \frac{Length\ of\ paddy\ (mm)}{Breadth\ of\ paddy\ (mm)}$$

Hulling percentage: The mud lumps, rice stems, leaves and other foreign matter from the sample were removed and then 100 g of sample was weighed. The clean sample was shelled with the Satake Sheller. The samples were hulled and weights of dehulled grains were recorded using following formula

$$Hulling\ percentage\ (\%) = \frac{Weight\ of\ dehusked\ kernel}{Weight\ of\ paddy} \times 100$$

Milling percentage: The hulled samples were milled and weight of milled grains was recorded using:

$$Milling\ percentage\ (\%) = \frac{Weight\ of\ polished\ kernel}{Weight\ of\ paddy} \times 100$$

Percentage of head rice (%): The percentage of the head rice was calculated using [18].

$$Percent\ head\ rice\ yield = \frac{Weight\ of\ whole\ grains}{Weight\ of\ paddy\ samples} \times 100$$

Kernel length (mm): Ten milled grains were taken randomly and average length was recorded in millimetre.

Kernel breadth (mm): Ten milled grains were taken randomly and average breadth was recorded in millimetre.

Kernel length: breadth (L/B) ratio: This was calculated using:

$$Kernel\ length{:}breadth\ \left(\frac{L}{B}\right) ratio = \frac{Length\ of\ milled\ grains}{Breadth\ of\ milled\ grains} \times 100$$

Cooking quality characters

Cooking procedure: 1-2 g of milled rice sample were 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 lined with filter paper. Ten cooked whole grains were selected and placed on a graph paper mounted with glass frame and following characters were recorded accordingly:

1. Kernel length after cooking (KLAC) (mm): Ten cooked kernel taken randomly and were arranged linearly on graph paper and average kernel length was recorded in millimeter.
2. Kernel breadth after cooking (KBAC) (mm): Ten cooked kernel taken randomly and were arranged horizontally, average kernel breadth was recorded in millimeter.
3. Elongation ratio (ER): This was calculated by using:

$$Elongation\ ratio = = \frac{Kernel\ length\ after\ cooking}{Kernel\ Length\ before\ cooking}$$

The gelatinization temperature (GT) was determined by the temperature at which the crystalline structures of the starch begin to melt. Rice with a high GT has a more crystallinity structure and contain high amount of long chain amylopectin [19].

Water uptake ratio: The water uptake ratio of rice was calculated from the amount of water absorbed by a known quantity of rice cooked in boiling water for a given time [20]. There are two stages involved in water uptake; the first stage involves starch gelatinization at a temperature between 70°C and 80°C, the second involves weakening of secondary bonds when temperatures reach over 90°C [21]. "Optimal time water uptake" occurs when cultivars are cooked until their opaque core disappears. This usually occurs when 2.5 g of water is absorbed per gram of rice [22].

Solid loss in gruel: Solid loss of cooked grains in gruel was determined by drying an aliquot of cooking water in a Petri dish at $100°C$ in a hot air oven until completely dry [23].

Amylose content: All the hulled, milled, cleaned samples having similar moisture content were grinded to a fine powder in a Wig-L-Bug amalgamator for 40 second. A UD cyclone mill with 1 mm sieve was also used for grinding. 100 mg rice flour was taken in long test tube (2x19.5 cm), after that 1 ml rectified spirit and 9 ml of 1.0 N NaOH were added to the test tube which was later thoroughly shaken and heated on water bath for 15 minutes for digestion. The digested sample was poured in a twice rinsed volumetric flask with hot distilled water and later for volume make up to 100 ml, double distilled water was added. 5 ml solution from volumetric flask was drawn in three replications in to three 100 ml volumetric flasks. For each 5 ml solutions add 1 ml of acetic acid and 2 ml of I_2-KI reagent was added and volume made up to 100 ml. All the flasks were covered with black cloth as I_2-KI looses colour when exposed to light. Spectrophotometer was adjusted to 620 nm for taking optical density. This obtained optical density was used in place of x in the equation y = bx to calculate amylose content.

Table-2 Cooking and eating characteristics of selected germplasm

Treatment	SL	SW	HL%	MR%	HRR%	MKL	MKW	L/B	SICW	CGL	CGW	WUR	GEDC	AMY	GC	GT
Chinudhan	6.063	2.46	78.1	71.597	56.41	5.043	2.207	2.44	0.093	8.23	4.117	3.337	1.63	89.73	6.247	24.303
Jhinidhan	5.763	2.15	80.25	80.77	52.713	4.847	1.943	2.683	0.093	7.21	4.11	3.533	1.493	89.427	7.24	26.537
Saaldhan	5.693	2.983	83.243	82.587	54.877	4.653	2.723	1.917	0.073	8.243	4.307	4.15	1.777	90.627	6.267	26.47
Sailadhan	6.41	2.537	70.903	70.42	40.457	5.123	2.343	2.537	0.073	7.9	4.41	3.757	1.543	91.597	5.233	26.12
Kaludhan	6.267	2.603	71.99	72.04	40.04	5.2	2.407	2.407	0.097	8.4	4.213	3.51	1.613	90.53	4.553	26.51
Kalijhini-1	5.943	1.787	75.27	75.257	50.167	4.62	1.543	3.36	0.053	8.11	3.81	3.847	1.753	90.01	4.76	29.24
Kalijhni-2	6.067	1.893	73.813	73.327	40.257	4.293	1.757	3.203	0.067	7.303	4.21	4.01	1.713	90.263	4.777	23.64
Ram Jawan Dhan	5.847	2.453	72.73	72.527	48.373	4.343	2.207	2.397	0.043	7.81	4.01	3.32	1.81	90.67	3.757	26.083
Sukra	6.05	2.79	76.073	75.79	46.42	5.077	2.543	2.183	0.067	7.81	4.61	2.91	1.543	71.607	6.017	26.303
Chohartu	5.573	2.753	75.667	75.333	46.623	4.617	2.537	2.013	0.053	8.25	3.91	3.563	1.783	84.283	5.513	28.3
Karad	5.773	2.677	70.88	71.303	43.313	4.213	2.41	2.16	0.063	7.21	3.41	3.8	1.707	75.437	5.747	25.66
Max	6.41	2.983	83.243	82.587	56.41	5.2	2.723	3.36	0.097	8.4	4.61	4.15	1.81	91.597	7.24	29.24
Min	5.573	1.787	70.88	70.42	40.04	4.213	1.543	1.917	0.043	7.21	3.41	2.91	1.493	71.607	3.757	23.64
C.D.	0.038	0.015	0.893	0.919	0.568	0.014	0.011	0.014	0.009	0.027	0.011	0.148	0.01	0.613	0.048	0.614
SE(m)	0.013	0.005	0.3	0.309	0.191	0.005	0.004	0.005	0.003	0.009	0.004	0.05	0.003	0.206	0.016	0.208
SE(d)	0.018	0.007	0.425	0.437	0.27	0.007	0.005	0.007	0.004	0.013	0.005	0.071	0.005	0.292	0.023	0.294
C.V.	0.376	0.344	0.691	0.718	0.7	0.169	0.29	0.322	7.518	0.197	0.151	2.392	0.351	0.412	0.517	1.37

SL=Seed length, SW= Seed width, HL=Hulling recovery, MR= Milling recovery, HRR%=Head rice recovery, MKL=Milled kernel length, MKW=Milled kernel width, L/B= Length/width ratio, SICW = Solids in cooking water, CGL=Cooking grain length, CGW=Cooking grain width, WUR = Water uptake ratio, GEDC = Grain elongation during cooking, AMY = Amylose content, GC = Gel consistency, GT = Gelatinization temperature.

Gel consistency (GC): Gel consistency was done by recording measurements using graph paper as per procedure followed by Bhonsle and Sellapan [24].

Gelatinisation temperature (GT): Gelatinisation temperature was determined based on ASV according to the classification given by Bhonsle and Sellappan [25].

Statistical Analysis: Suitable statistical tools were used for analysis of the data. One way ANOVA was applied to the data pertaining to physicochemical properties, nutrient composition, and antioxidant activity and cooking quality of aromatic and non-aromatic varieties. Independent t-test was applied to compare quality parameters between non-aromatic and aromatic varieties. Correlation was applied to determine whether or not two variables are correlated.

Result and discussion

Grain quality is the most important factor considered by plant breeders. Although the demand for rice is likely to increase, the rice breeding stations and institutions had tried to improve indigenous rice for yield parameters along with cooking qualities. In the present study, we performed experiment to record the physicochemical and cooking properties of landraces cultivated in Aus season. We assessed the physico-chemical and cooking quality characteristics in selected land races grown in foot hills of Himalayan region

Physical qualities rice: Physical qualities like milling per cent, head rice recovery, thousand grain weight, volume weight, grain shape and size of rice varieties were evaluated and are presented in Table 2. The results pertaining to the physical qualities are as follows.

Grain size of rice germplasm in terms of grain length, grain width and L/B ratio is presented in Table 2. Among eleven rice germplasm, the length of rice grain was found to be the highest in Saladhan (6.41 mm) followed by Kaludhan (6.267mm) and Kaliijhini-2 (6.067mm) and the lowest in Chohartu (5.57 mm). The grain width was found to be the highest in Saaldhan (2.98mm) followed by Sukra (2.79 mm) and Karad (2.67 mm) and lowest in Kalijhini-1(1.78 mm).[26] reported similar results using a set of aromatic rice genotypes from India.

Length and breadth ratio: Length and breadth ratio of rice varieties were determined and enumerated in Table 2. The highest length and breadth ratio of 3.36 was noticed in khalijhini-1 followed by Kalijhini-2 (3.203), Jhinidhan (2.68) and Sailadhan (2.53) and the lowest of 1.91 in Saaldhan (1.91). In a study on 20 new plant type genotypes, Sandeep (2003) and Hossain *et al* (2009) reported kernel length/width ratio of cooked rice ranging from 2.04 to 3.95 and 2.39 to 5.07 respectively. A low value of l/ b ratio observed indicates poor cooking quality [27].

Hulling recovery (%), milling recovery (%) and head rice recovery Among eleven rice germplasm, the hulling recovery percentage of rice grain was found to be the highest in Saaldhan (83.24 %) followed by Jhinidhan (80.25 %) and Sukra (76.07 %) and the lowest in Karad (70.88 %). The milling recovery was found to be the highest in Saaldhan (82.58 %) followed by Jhinidhan (80.77 %) and Sukra (75.79 %) and lowest in Sailadhan (70.42 %). Head rice recovery the head rice recovery of rice varieties was assessed. The head recovery percentage of rice grain was found to be the highest in Chinudhan (56.41 %) followed by Saaldhan (54.87 %) and Jhinidhan (52.71 %) and the lowest in Kaludhan (40.04 %). According to Dipti *et al* (2002) good quality rice will have an HRY of least 70% based on which claimed that all germplasm lines are intermediate in terms of HRY% [28].

Milling kernel length and width: highest milling kernel length was observed in kaludhan (5.20 mm) followed by Sailadhan (5.12 mm), Sukra (5.07 mm) and Chinidhan (5.043 mm) and lowest in Kalijhini-2 (4.21 mm), whereas highest milled kernel width was observed in Saaldhan (2.72 mm) followed by Sukra (2.54 mm), Chohartu (2.53mm) and Karad (4.21 mm) and lowest milled kernel width was observed in Kalijhini-1 (1.54 mm). Rice yield with above 70% head rice percentage are considered as good quality rice [29].

Cooking qualities of rice Cooking qualities of the raw rice namely, the solid in cooking quality, cooking grain length, cooking grain width, water uptake ratio, grain elongation, gelitization temperature, amylose content and gel consistency were analyzed among selected Himachal Pradesh germplasm. The results are as follows.

Cooking grain length and width rice varieties is given in Table 2. the highest cooking grain length was observed in Kaludhan (8.40 mm) followed by Chohartu (8.25 mm), Saaldhan (8.24 mm) and Chinudhan (8.23 mm) and the lowest of 7.21mm in Jhinidhan variety, whereas the highest cooking kernel width was observed in Sukra (4.61 mm) followed by Sailadhan (4.41 mm), Saaldhan (4.31 mm) and Kaludhan (4.21) mm and the lowest observed in Karad (3.41 mm).

Solid in cooking quality of selected germplasm of rice varieties varied from 0.097 in Kaludhan to 0.043 in Ramjawandhan. During cooking, loose of gruel observed with range from 0.80% in Ofada 8 to 2.10% in Ofada 3 with average 1.25% [30].

Water uptake: The water uptake by rice while cooking is presented in Table 2. Among eleven germplasm, the highest water uptake of 4.15 ml/ g was observed in

Saaldhan variety followed by 4.01 ml/ g in Kalijhini-2 and 3.80 ml/ g in Karad. Among different varieties under study, Sukra obtained the lowest water uptake of 2.19 ml/ g. All the Ofada rice samples had WU within this range, indicating good cooking quality. At a higher WU (300 to 570%), majority of rice shows pasty appearance which is not favorable for cooking and eating quality [31].

Grain elongation: Grain elongation ratio of eleven germplasm is presented in Table 2. Among the selected germplasm, maximum grain elongation ratio of 1.81 was observed in Ramjawndhan followed by Chohartu (1.78), Saaldhan (1.77) and Khalijhini-1 (1.75). Jhinidhan obtained the lowest grain elongation ratio of 1.493 among eleven germplasm. reported kernel elongation ratio of 20 newly identified inter sub-specific (indica/ japonica) rice hybrids ranged from 1.51 to 1.82, while Shobha (2003) reported 1.70 to 2.00 in nine released hybrid rice varieties in India [31].

Gel consistency: Gel consistency of rice germplasm were determined by measuring gel length and furnished in Table 2. Among selected germplasm of rice varieties maximum gel length of 91.59 mm was noticed in Sailadhan followed by Ramjawandhan (90.67 mm), Saaldhan (90.62 mm), Kaludhan (90.53 mm) and Khalijhini-2 (90.23 mm). The lowest gel consistency among selected germplasm was observed in Sukra (71.60 mm).

Gelatinisation temperature index of germplasm were subjected to the alkali digestion test and were visually observed to evaluate the degree of disintegration in alkali. After the stipulated time of observation, little effect was observed among selected rice germplasm. All the rice varieties were found to be of high gelatinization index. Highest gelatization temperature was found in Jhinidhan (7.24) followed by Saaldhan (6.267), Chinidhan (6.24) and Sukra (6.017) and lowest temperature observed in Ramjawandhan (3.75). Similar alkali spreading values have been recorded by [32] in their study on scented rice varieties.

Amylose content: The amylose content of rice varieties were assessed and are given in Table 2. The highest amylose content among selected germplasm was observed in Kalijhini-1 (29.24 %) followed by Jhinidhan (26.53 %), Saaldhan (26.47 %) and Sukra (26.30 %).The result are on par with observation made earlier [33].

Conclusion

Among the 11 landraces, Saaldhan has the highest kernel width (2.98 mm), Hulling recovery (83.24%), milling recovery (82.58%), milled kernel length (2.73 mm) and water uptake ratio (4.15%), while as, Karad had lowest hulling recovery (70.88%), milled kernel length (4.21 mm), cooking grain width (3.41 mm). Amylose content (23.24-29.24) showed non-significant differences between the varieties, Head rice recovery was below 60% in the all the varieties.

Application of research: Research is applicable for the characterization of rice landraces and comparing with recently released varieties for its physiochemical and cooking superiority.

Research Category: Rice Germplasm

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