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# Cooking Quality and Yield Analysis of Extra-ordinary Long Grain Rice of Pakistan

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**Abstract.** Rice is one of the primarily grown cereals in the universe and is eaten by 60% of the world population as a staple food. Three indigenous extra long grain rice varieties grown in Punjab, Pakistan were analyzed for their cooking, chemical and physical properties. A comparison of newly developed varieties was done with the existing Basmati 515, super Basmati. Among all studied traits, varieties differ considerably at $P > 0.001$ value for paddy yield, plant height, grain dimensions, elongation/expansion ratio, gel uniformity, temperature for gelatinization, alkaline spread value and aroma on sensory perception. The volume expansion ratio varied from 4.5 to 5.5. The highest volume expansion ratio was acquired for Kissan Basmati. Grain elongation after cooking ranged between 14.7 to 16.6 mm. The values for the amylose ranged between 22.50 to 24.0% and amylopectin ranged between 76-77.5%. The range of AGL of extra long grain ranged from 8.10 to 8.23 mm, L/B ratio from 4.47 to 5.47. All verified varieties showed resistance against BLS, blast and BLB incidence.

**Keywords:** rice, cooking, long grain varieties, basmati, amylose, ASV, yield, BLB

## Introduction

Rice is one of the primarily grown cereals of the world and is eaten by 60% of the world population as a staple food. It accounts vital role in global food security particularly in fulfilling the calorie requirement. Globally, 90% of production and consumption befall in Asia only. International rice trade bulk has augmented nearly six-fold after the 1960s to date. Pakistan is earning good foreign exchange value through the export of long grain Basmati rice varieties *i.e.*, Basmati 515 and super Basmati. Rice production is expected to surge by 40% by 2030 to encounter the expected, which has to be challenged by decreased land and restrictive water along with the special emphasis on climate change (Khush, 2005). To meet this target fertilizer responsive, high yielding and disease/pest resistant varieties have to be developed. The major constraint is to sustain the grain and cooking quality, while breeding for improved new rice cultivars (Bandumula, 2018).

Rice (*Oryza sativa*) has two main subspecies: long grain rice, *Indica* and round-grain, *Japonica* (cultivated and consumed in China, Korea, Australia, the European Union countries, Taiwan, Japan, USA, Turkey and Russia). *Indica* type rice varieties are generally grown in Asian countries. These varieties are also categorized as fragrant and valued as premium (Salgotra *et al*., 2018).

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Four types of rice are traded globally *Indica* (80%), *Japonica* (15%), aromatic (Basmati and Jasmine (4%) and glutinous (1%) rice. Aromatic rice has a limited market share by India and Pakistan only (Siddiq *et al*., 2012). Basmati varieties entirely cultivated on the Himalayan foothills of India and Pakistan (Priya *et al*., 2019). Continuous exploration in breeding technology has enabled Pakistan to rationalize the expanding local and global demand. During the last few years, 14% decline in rice export was detected owing to massive local consumption and low demand of short grain rice varieties. Efficient yield giving and long grain cultivars can be a sustainable option to fetch trade benefits. There is a different meaning of efficient or premium variety for farmers, traders, growers. As farmers need early maturing and higher yielding cultivars which offer them enough time for sowing of next crops. Besides, growers and traders of rice have different interests (Khan and Khan, 2010).

A long grain variety Basmati 515 was introduced by rice Research Institute, Kala Shah Kaku, Lahore, Punjab, Pakistan. Its quality was found better than super Basmati *i.e.*, elongation ratio (2.10). (Akhtar *et al*., 2015). Its demand has been decreasing in markets as buyers are now demanding extra-long grain varieties (more than 8.0 mm grain length) with acceptable cooking qualities (Akhtar *et al*., 2019).

Cereal quality especially rice grain is very important to be accepted by the people for cultivation/consumption. Quality is determined by certain physical properties like milling recovery, % degree of milling, kernel dimensions and physico-chemical characteristics *i.e.*, temperature for gelatinization (GT), apparent amylose content (AC) and gel consistency (GC). Cooking/eating qualities are administered by physico-chemical properties in the case of rice. Cooking and eating belongings of milled rice shows an important role in consumer preference, particularly flavour, texture and aroma. Rice structure and composition have a surprising association with cooking and eating properties. Grain quality classification is based on the length, *i.e.*, short, medium and long. Grain shape is a vital agronomic trait in cereal crops because it is related to quality and quantity (Tan and Corke, 2002). Moreover, it is the foremost quality characteristic measured in evolving innovative varieties. A length/breadth ratio ranging from 2.5 to 3.0 is widely accepted and a grain length > 6 mm is favoured (Juliano, 2003). Some people prefer short grains like in Himalayan region; the medium grains in south Asian region and most commonly people in the Indian subcontinent and in the international market like slender long grains. Thus, components of advent traits are one of the first standards for breeders in the release and commercial production of varieties (Nadvornikova *et al*., 2018). Therefore, this study was designed to evaluate the recently developed extra long grain varieties of rice by Rice Research Institute, Kala Shah Kaku, Lahore. Existing long grain Basmati varieties *i.e.*, Basmati 515 and Super Basmati used as a check.

## Materials and Methods

**Field data.** Three extra long grain rice varieties along with existing long grain varieties were sown at the farm area of rice Research Institute, Kala Shah Kaku, Lahore for three consecutive harvesting seasons (2017-2020) adopting standard production technology. A randomized complete block design (RCBD) with three replications was used.

**Grain yield parameters.** At physiological maturity, grain yield was measured. A graduated meter rod was used to measure plant height (cm) at the time of maturity. Days to maturity (DM) was calculated by counting the number of days from sowing upto the 80-85% maturity of grains by following the method developed by Rice Analysis Method (1980).

**Pathological parameters.** All varieties were screened for attack of Brown leaf spot (BLS), bacterial leaf blight (BLB) and rice blast. Following scale was used: resistant (R), susceptible (S), moderately resistant (MR), moderately susceptible (MR) Rice Analysis Method (1980).

**Lab data.** Three rice varieties were picked according to the maturity level of each variety from farm sites of Rice Research Institute, Kala Shah Kaku. Manual pre-cleaning of samples was done to remove dust, dirt and straw. Moisture contents of samples were checked by a digital moisture meter. Dehusking was carried out on Lab Sheller and then abrasion type rice polisher (McGill Miller, USA) was used for obtaining white rice, then grading was done on laboratory rice rotary sieve (SATAKE TRG058, Japan) for separation of healthy head rice from broken of each sample. Obtained samples were used for quality analysis.

Ten randomly picked healthy kernels in three sets were taken, length and breadth of each grain were measured by placing it on a micro-scale. The length breadth ratio, the kernel elongation was calculated by the method developed by Rice Analysis Method (1980. The degree of spreading of rice kernel in an alkaline solution was gauged on a 7-point numerical scale as gelatinization temperature Rice Analysis Method (1980). Amylose and protein contents were measured by auto grain analyzer AN-900 KETT Japan. Gel consistency of rice flour was measured by following the method (Cagampang *et al*., 1973).

**Statistical analysis.** Results obtained were examined statistically by the Analysis of Variance (ANOVA) procedure employing Statistix software version 10. Differences were compared at $P < 0.05$. Where significant variances were detected, the means were scrutinized by Least Significant Difference (LSD) method at a 5% probability level.

## Results and Discussion

Grain quality in rice is tough to describe with precision as liking/disliking varies from country to country. Few people realize its complexity because quality varies according to the preparations for which grains are to be finally used. Results summarized for the different physico-chemical characteristic of paddy and rice are as below:

On average, Kissan Basmati matured twenty-one days (21) before Super Basmati and Basmati-515 as depicted in Table 1. Likewise, PK 2021 aromatic matured twelve days (12) former than Super Basmati and Basmati-515. Presently, the plant height of PK-1121 aromatic (115 cm) is almost equivalent to Super Basmati and Basmati 515 (120 cm).

Yield is the key final quantitative character regulated by environmental factors and quantitative trait loci. It relies on the following factors *i.e*., no. of tillers, plant height, maturity days, length of panicle, kernel setting rate, 1000 grain weight and filled grain on panicle (Li *et al*., 2019). Kissan basmati presented the shortest plant height among all varieties. Results of the average yield of PK 2021 aromatic showed a 6.02% increase in yield over Super basmati. There is a 30% additional average yield of Kissan Basmati (3.48 t/ha) and 10% more for the Basmati-385 (3.16 t/ha) as compared with the check variety (Super Basmati (2.68 t/ha). Similar findings were reported by (Akhtar *et al*., 2015).

Table 2 exhibited the disease incidence impact on tested varieties. Slight variances among the varieties occur at a confidence interval of 95%. The rice crop is vulnerable to many diseases among which BLB is the most distressing and critical disease throughout universe. BLS is also a matter of serious concern in other parts of Asia especially the Basmati areas (Arshad *et al*., 2020).

Grain quality included length, grain elongation during cooking (mm), L/B ratio, cooked grain length and bursting %. Momentous correlations detected among the physico-chemical and quality features as shown in the Table 3. On an average, rice grain length of tested varieties was above 8.00 mm as compared to existing long grain rice varieties of marker along with a good elongation ratio. These results are in line with many researcher's findings that Basmati rice has very exciting cooking behaviour. Basmati varieties are non-glutinous, non-waxy in nature, does not stick on cooking, flaky feel, extraordinary lengthwise expansion and soft texture even after cooling (Cagampang *et al*., 1973). Mostly, breadthwise proliferation on cooking of rice is considered an unwanted trait, while premium quality varieties shows increase in length after cooking (Singh *et al*., 2013). The first look of milled rice is imperative for customer because size and shape is considered in developing new varieties for release for commercial cultivation by breeders (Thomas *et al*., 2013).

In all basmati varieties L/B ratio fall between 4.19 to 5.16 as depicted by Table 3. Customers usually choose rice with a translucent endosperm and are ready to pay best price for it, even opacity dissolves during the course of cooking and final texture does not alter due to it. Long-type landraces are still ideal for native people of Indo-Pak (Shaeed *et al*., 2017; Hsu *et al*., 2014). It was reported in a study by (Wanchana *et al*., 2003) that local varieties had bolder grains having width from 2.21 to 2.26 mm compared with 1.96 mm for the other existing check varieties. This similar result was endorsed by (Singh *et al*., 2005) in experiment.

Amylose content of research varieties displayed significant results as depicted in Table 3. As Basmati varieties and their parentage were close to each other. Singh *et al*. (2005) added that intermediate amylose content (20-25%) is widespread in Basmati rice cultivated in

**Table 1.** Field data

| Yield parameter | PK 1121 Aromatic | Kissan basmati | PK 2021 aromatic | Basmati 515 | Super basmati |
|---|---|---|---|---|---|
| Av. Grain yield (t/ha) | 6.00[a] | 5.50[b] | 5.30[c] | 5.00[d] | 4.10[e] |
| Maturity days | 116[a] | 94[d] | 103[c] | 115[b] | 115[b] |
| Plant height (cm) | 115[c] | 98[d] | 116[c] | 130[a] | 120[b] |

**Table 2.** Pathological evaluation

| Level of resistance | PK 1121 Aromatic | Kissan basmati | PK 2021 aromatic | Basmati 515 | Super basmati |
|---|---|---|---|---|---|
| Bacterial leaf blight (BLB) | MR | MR | MS | S | S |
| Blast | MS | MR | MS | MS | MS |
| Bacterial leaf spot (BLS) | MR | MR | MS | MS | MS |

MR = Moderately resistant (5); MS = Moderately susceptible (7); S = Susceptible (9); R = Resistance (3). This 0-9 scale is used for the estimation at disease affected leaf area. This disease scoring was done by following the Standard Evaluation System for Rice (SES), 5$^{th}$ edition, 2013.

**Table 3.** Cooking quality parameters of rice

| Cooking characteristics | PK 1121 Aromatic | Kissan basmati | PK 2021 aromatic | Basmati 515 | Super basmati |
|---|---|---|---|---|---|
| Av. grain length (mm) | 8.20$^{b}$ | 8.10$^{c}$ | 8.23$^{a}$ | 7.38$^{e}$ | 7.44$^{d}$ |
| Length/breadth ratio | 4.77$^{b}$ | 5.47$^{a}$ | 4.47$^{d}$ | 4.47$^{d}$ | 4.59$^{c}$ |
| Gel consistency | Soft$^{NS}$ | Soft$^{NS}$ | Soft$^{NS}$ | Soft$^{NS}$ | Soft$^{NS}$ |
| Gelatinization temperature | Intermediate$^{NS}$ | Intermediate$^{NS}$ | Intermediate$^{NS}$ | Intermediate$^{NS}$ | Intermediate$^{NS}$ |
| Amylose contents (%) | 23.00$^{d}$ | 22.50$^{e}$ | 24.00$^{a}$ | 23.40$^{c}$ | 23.80$^{b}$ |
| Alkali spread value | 5.00$^{b}$ | 5.80$^{a}$ | 4.50$^{d}$ | 4.50$^{d}$ | 4.70$^{c}$ |
| Cooked rice length (mm) | 16.48$^{b}$ | 16.60$^{a}$ | 14.70$^{d}$ | 15.40$^{c}$ | 14.37$^{e}$ |
| Elongation ratio (E/R) | 2.02$^{c}$ | 2.05$^{b}$ | 1.80$^{e}$ | 2.08$^{a}$ | 1.93$^{d}$ |
| Vol. expansion ratio | 4.80$^{b}$ | 5.50$^{a}$ | 4.50$^{d}$ | 4.50$^{d}$ | 4.60$^{c}$ |

*Gel consistency: Hard (41-60 mm); Intermediate (61-100 mm) Soft (below 40 mm); ** = Alkali score (1-7): High GT (1-3), Intermediate GT (4-5); Low GT (6-7).

Pakistan and India amylose content above 25% limits the rice quality and is inversely allied to stickiness which is a specific factor for Japonica rice. Wu *et al*. (2018) elaborated that rice having an intermediate amylose content has low gelatinization temperature whereas rice with low or waxy amylose content has a high gelatinization value (Prakash and Jamuna, 2007).

Alkali spread value is one of the key gauge of gelatinization temperature as categorized into three groups namely, low, intermediate and high. In the present study all varieties fall under the intermediate group. Insignificant results were depicted by all Basmati cultivars for ASV. There is a contrari wise relationship between alkali digestion assessment and the gelatinization temperature, the genotypes with low alkali digestion have a high gelatinization temperature (Yadav *et al*., 2014). Alkali spread values are dependent on the nature of the amylopectin molecules (Shaeed *et al*., 2017; Prathepha *et al*., 2005). Gel consistency noticed the cold paste viscosity of milled rice in distinguishing cooked texture of high amylose genotypes. All long and extra long grain rice genotype fall under the category of soft gel which is indicative of Basmati blood as stated in Table 3. The gel consistency test was initiated as an indirect method in screening hardness for cooked rice (Subedi *et al*., 2016). Hard gel consistency was observed in non basmati/short grains due to the development of rigid gels due to association of starch polymers in the aqueous phase. Starch granules leach down when rice is heated and subsequently cooled (Dhaka *et al*., 2020; Hegde *et al*., 2013; Asghar *et al*., 2012).

Linkage of starch polymers in the aqueous phase controls the weak and rigid gels. Rice having soft gel is liked by most consumers. Short grain rice types harden faster than those with long grain soft gel consistency, when cooked. Rice forming soft gel cooks tender and leftovers remain soft even after cooling. Negative correlation between amylose content and gel consistency is reported by many researchers (Calingacion *et al*., 2014; Yan *et al*., 2011). Soft gelatinization means soft and moist texture after cooking and this also explains the tenderness and sticky nature of these varieties (Hossain *et al*., 2009).

## Conclusion

Above 92% of basmati rice production in Pakistan comes from Punjab due to prominent 07 basmati varieties of which Super Basmati and PK-1121 aromatic are the dominant varieties occupying over 69.2% and 28.3% of the total area. However, international demand is continuously rising for extra long grain rice. Indian basmati varieties are gaining good trade earnings but Pakistan has a limited share in world trade due to varietal purity and quality issues. Kissan Basmati and PK 2021 aromatic can be brought additional revenue due to their yield potential, higher grain length, good elongation after cooking and disease resistance.

**Conflict of Interest.** The authors declare that they have no conflict of interest.

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