Research Article

Impact of Quality Analysis Assessment of Various Rice Traits Enhancing Cultivation and Nutritional Value

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Abstract: Rice is a staple food widely consumed across the world, particularly in Asia. Its consumption patterns vary by region, with different varieties and types of rice preferred in different cultures. Despite rice's central role in global nutrition and its significant contribution to caloric intake, comprehensive studies on the quality characteristics of different rice varieties are limited. This study aims to fill this gap by evaluating the physical, chemical, and cooking properties of rice samples from two distinct varieties, GQTL 1401 Sample01 and Sample02, collected from the National Agricultural Research Center, Islamabad. The evaluation covers physical traits like length, breadth, and thickness, as well as chemical parameters such as moisture content, amylose content, crude fiber, crude fat, and ash content. In addition, cooking tests, including stickiness, aroma, and taste, are conducted to assess the cooking quality of the rice. The findings of this study will contribute valuable insights into the quality characteristics of rice, supporting efforts to improve rice cultivation and nutritional value.

Keywords: Rice varieties, quality evaluation, physical analysis, chemical analysis, amylose content, cooking characteristics, nutritional value.

Introduction

Rice (*Oryza sativa L.*) is a globally cultivated cereal crop (Mbanjo *et al*., 2020) with more than 90% being grown and consumed in Asia (Sultana, *et al*.,2022). It is considered a dietary staple for around half of the global population (Khush *et al*., 2005). Rice, a staple food consumed by billions globally, plays a significant role in the daily diet (Sinthuja, *et al*., 2021), especially in Asia. It is the primary source of calories for more than 3 billion people, contributing to over 20% of the total caloric intake worldwide. These traditional varieties, which are more widely cultivated due to their medicinal values and resistance to diverse soils and weather conditions, offer greater variability in grain nutrition, texture, and aroma compared to improved varieties (Abeysekera, *et al*., 2021; Rohman, *et al*., 2014). The cultivation of rice, particularly *Oryza sativa* and *Oryza glaberrima*, has been practiced for millennia, originating in tropical Asia and extending to temperate regions (Rebeira, *et al*., 2014). Rice is grown in over 150 million hectares worldwide, with Asia being the dominant producer, accounting for more than 90% of the global rice production (Abeysekera *et*

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al., 2008). Due to variations in cooking methods, biochemical and physical properties, and processing conditions, classifying rice grain quality can be challenging. Key quality parameters are categorized into four aspects: milling, cooking, sensory evaluation, and appearance (Sultana, *et al*.,2022). The different varieties of rice have distinct physical, chemical, and culinary characteristics that influence consumer preferences and their nutritional contributions. (Hettiarachchi, *et al*., 2016).

Rice varieties are typically classified based on their grain type, including short-grain, medium-grain, and long-grain, as well as their cooking and sensory attributes (Hettiarachchi, *et al*., 2016). For instance, Japonica varieties, popular in Japan, are sticky when cooked, whereas Indica varieties, common in India and Southeast Asia, are typically less sticky and have a firmer texture (Sultana, *et al*.,2022). Other factors, such as the presence of amylose, the major component of starch in rice, determine cooking behavior and the final texture of the rice. (FAO, 2002).

While significant research has been conducted on the nutritional content and cooking properties of rice, there is a dearth of comprehensive studies evaluating the overall quality characteristics of different rice varieties. This study aims to bridge this gap by assessing the physical, chemical, and cooking properties of two rice varieties: GQTL 1401 Sample01 and Sample02, sourced from the National Agricultural Research Center, Islamabad.

Materials and Methods

The rice samples, GQTL 1401 Sample01 and Sample02, were obtained from the National Agricultural Research Center (NARC) in Islamabad. These samples were selected for their distinct cultivation backgrounds and were subjected to comprehensive physical and chemical analysis at the Food Science Research Institute, NARC during the winter season of 2023/2024. The rice paddy was milled to remove the outer husk and prepared for analysis. The milled rice samples were stored at ambient temperature before being subjected to physical and chemical analyses. After milling, the rice samples were cooked under controlled conditions for further analysis of their cooking properties. Prior to any chemical analysis, the rice was polished to reduce the risk of oxidative rancidity, which can occur during storage. The physical properties of the rice samples were analyzed by measuring the length, breadth, and thickness of ten randomly selected grains from each variety using a micrometer. These measurements were recorded, and the average dimensions were calculated for both rice varieties. The alkali spreading value (ASV) was determined according to the procedure described by (Sultana *et al*., 2022), which assesses the gel consistency of rice starch by testing its behavior in an alkali solution. Additionally, the rice grains were subjected to a "bursting" test using the Heater Method to determine the expansion and cooking behavior under heat (FAO,2006). Aroma tests were performed using the paraffin method to assess the presence of any volatile aromatic compounds, which contribute to the rice's fragrance during cooking (FAO, 2008).

Cooking Analysis

The rice samples were cooked at a controlled temperature. After cooking, the weight of the rice was measured to assess water absorption and yield. Sensory evaluations, including aroma and stickiness, were conducted to assess the culinary quality of the rice varieties (Cruz *et al*., 2000).

Chemical Analysis

Moisture content in the rice samples was determined by drying the rice at 130°C for 1 hour in a hot air oven (Lapis, *et al*., 2019), (AOAC, 2006). The weight loss was recorded, and the moisture content was calculated using the formula:

Moisture Content=Initial Weight−Final weight / Initial weight×100

Amylose Content

Amylose content was determined using a spectrophotometric method based on the modified technique of (Juliano *et al*., 1971). The optical density was measured, and the amylose content was calculated using the following formula:

Amylose Content = (Optical Density × Slope of Calibration Curve Dilution Factor) \ {Amylose Content} = (\text {Optical Density} \times {Slope of Calibration Curve} \times \text {Dilution Factor}) Amylose Content = (Optical Density Slope of Calibration Curve × Dilution Factor)

The standard value used in the calculations was 3.68.

Crude Fiber

The crude fiber content was determined by subjecting the rice samples to acid and alkali treatment. The digestion of all organic contents except fiber was achieved under reflux conditions, after which the extracted fiber was separated, dried, and ignited to determine its weight (Hafeel *et al*., 2008), (AOAC, 945.38 F; 920.39 C official methods (Prapasri *et al*., 2011).

Crude Fat

Crude fat was extracted from the rice samples using n-hexane at its boiling point. After extraction, the solvent was evaporated, and the remaining fat content was determined by weighing (Rather *et al*., 2016).

Ash Content

Ash content, which reflects the mineral composition of rice, was determined by incinerating the rice sample at temperatures between 450-600°C. The remaining inorganic residue was weighed to determine the ash content, following AOAC Method No. 923.03 (AOAC, 2006).

Physical Properties

The physical properties of the rice samples, including grain length, breadth, and thickness, varied between Sample01 and Sample02. Sample01 exhibited a longer grain length compared to Sample02, which was slightly shorter. The alkali spreading value indicated that Sample01 had a higher amylose content, contributing to its firmer texture after cooking. The bursting test confirmed that Sample01 had better expansion properties, indicating it was more suitable for dishes requiring fluffier rice.

Chemical Properties

The moisture content in both rice samples was found to be within the typical range for milled rice, with Sample02 having a slightly higher moisture content than Sample01. The amylose content was higher in Sample01, which aligns with its firmer cooking properties. Crude fiber content was low in both samples, reflecting the typical low-fiber nature of white rice. Crude fat content was also low, as expected, with Sample01 having a marginally higher fat content than Sample02. Ash content was higher in Sample02, suggesting a slightly higher mineral content.

Cooking Properties

Both rice varieties displayed distinct cooking characteristics. Sample01 exhibited a less sticky texture, making it ideal for pilaf or fried rice. In contrast, Sample02 had a slightly stickier texture, suitable for dishes like sushi or risotto. Aroma tests revealed a stronger fragrance in Sample01, likely due to its higher amylose content (Bhattacharya *et al.,* 1971).

Results and Discussion

The quality analysis of various rice traits is elaborated in tables below.

Table 1: Physical quality analysis of Sample 1

Replication	Length (mm)	Breadth (mm)	Thickness (mm)	L/B Ratio (mm)	Quality Index (mm)
R1	7.561	1.686	4.48	1.622	2.758
R2	7.675	1.713	4.484	1.634	2.75
R3	7.487	1.634	4.581	1.584	2.887

Table 2: Physical quality analysis of Sample 2

Replication	Length (mm)	Breadth (mm)	Thickness (mm)	L/B Ratio (mm)	Quality Index (mm)
R1	7.24	1.745	4.15	1.63	2.45
R2	7.56	1.71	4.41	1.64	2.68
R3	7.44	1.69	4.38	1.61	2.76

Table 3: Alkali Spreading

Score	Spreading	Alkali Digestion	Gelatinized Temp
01	Kernel not affected	Low	High
02	Kernel swallowed	Low or Intermediate	High
03	Kernel swallowed collar complete or narrow	No	High or Intermediate
04	Kernel swallowed collar complete or narrow and wide	-	Intermediate
05	Kernel split or segmented	-	Intermediate
06	Kernel dispersed, merging with Roller	High	Low
07	Kernel completely dispersed and Intermingled	High	Low

Code 1401, Sample 01

01	Kernel not affected	Low	High

Code 1401, sample 02

06	Kernel dispersed, merging with Roller	High	Low

Table 4: Bursting of Rice Analysis of different rice varieties

Variety	Sample (grains)	Curl rice	Bursting rice	Ratio %
Sample 01	50	14	13	27
Sample 02	50	8.5	20.5	29
Empty Petri Dish = 45.2623		Empty Petri Dish = 52.9892		
Sample = 0.8258		Sample = 0.6925		
Distilled Water =20ml 20min cooked at 300 ˚C		Distilled Water =20ml 20min cooked at 300 ˚C		
After Cooking Wt =41.984		After Cooking Wt =56.2901		
W.A.R =4.1705		W.A.R = 4.7752		
Curling = 14%		Curling = 8.5%		
Bursting =13%		Bursting =20.5%		
Volume Expansion = 12.5mm		Volume Expansion = 11.5mm		
Aroma = Strong		Aroma = Normal		
Stickiness = 3.5/5		Stickiness = 3.5/5		

Table 5: Amylose Content of Rice Varieties

Variety	Result	Amylose Content
Sample 01 (R1)	20.32	20.66
(R2)	21.77	
Sample 02 (R1)	17.85	13.13
(R2)	17.95	

Table 6: Gel Consistency of different Rice Varieties

Variety	Length (mm)	Result
Sample 01	90	Soft gel consistency
Sample 02	85	Soft gel consistency

Table 7: Aroma Estimation of Rice Varieties

Sample	Amount of sample	Aroma
Sample 01	0.5g	Present (very much)
Sample 02	0.5g	Present

Table 8: Ash Content of Different Rice Variety

Sample	Crucible wt.	Sample wt.	Final wt.	Ash %	Mean%
R1	21.7735	3.003	21.7889	0.152	0.321
R1	19.6679	3.0062	19.6821	0.472	
R2	19.8432	3.0084	19.8571	0.462	0.48
R2	20.2564	3.0084	20.2714	0.498	

Ash (%) = $\frac{\text{weight of Ash - crucible weight}}{}$ × 100 = $\frac{W3-W2}{}$ × 100 Weight of sampleW2

Table 9: Moisture Content of Different Rice Varieties

Sample	Empty Dish Wt.	Sample Wt.	Initial Wt.	Final Wt.	Moisture%	Mean%
Sample (R1)	11.2343	2.0168	13.2511	12.9512	14.87	14.84
(R2)	11.223	2.00819	13.2304	12.9325	14.82	
Sample (R1)	11.2019	2.0075	13.2094	12.9120	14.81	14.73
(R2)	11.2681	2.0027	13.2708	12.9773	14.65	

Moisture% = $\frac{\text{Initial Wt – Final Wt}}{\text{Wt. of Sample}} \times 100 = \frac{W3-W1}{W2} \times 100$

Table 10: Fiber Content of Rice Verities

Sample	Wt. of sample (g)	Wt. before Ashing (g)	Wt. after Ashing (g)	%Wt. of Fiber
Sample 01	2.1585	22.7898	22.7818	0.37
Sample 02	2.1136	21.7460	21.7289	0.81

Crude fiber Percentage = $\frac{W1 - W2}{\text{Wight of sample}} \times 100$

Table 11: Determination of Fat in different Rice Varieties

Sample	Beaker Wt. (g)	Sample Wt. (g)	Final Wt. (g)	Fat%
Sample 01	85.0843	3.0052	85.0972	0.42
Sample 02	85.0778	3.0275	85.0940	0.540

Physical Quality

The results for the length, breadth, thickness, L/B ratio, and quality index for Sample 01 and Sample 02 are elaborated in Table 1 & 2. Where the length of sample 01 had a higher length (7.675 mm) compared to sample 02 (7.44 mm) followed by breadth of sample 02 showed a higher breadth (1.74 mm) compared to sample 01 (1.686 mm) and thickness of sample 01 had a thickness of 4.48 mm, while sample 02 had a slightly higher thickness of 4.484 mm. The L/B ratio and quality index values indicate the overall size and quality of the grains, with sample 01 having slightly higher values compared to sample 02.

Alkali Spreading

The alkali spreading scores for the two samples is shown in Table 3. The alkali spreading test indicated that sample 01 had a higher alkali spreading value (Score 01), corresponding to a low gelatinization temperature. In contrast, sample 02 had a lower alkali spreading score (Score 06), indicating a higher gelatinization temperature.

Amylose Content

The amylose content of both rice samples was measured and presented in Table 5. Sample 01 amylose content ranged from 20.32% to 21.77% and sample 02 amylose content ranged from 13.13% to 17.95%. Moreover, sample 01 showed a significantly higher amylose content than Sample 02, indicating a more firm and less sticky cooked rice.

Gel Consistency

Gel consistency tests in table 6 showed that both rice varieties exhibited soft gel consistency, as evidenced by gel lengths exceeding 70 mm. This soft gel consistency is typically associated with lower amylose content, which is consistent with the findings for sample 02.

Ash Content

In Table 8 the ash content results for both rice varieties elaborates Ash content = 0.321% in sample 1 and 0.48% in sample 2, respectively. Sample 01 had a lower ash content than sample 02, which suggests that Sample 01 may have undergone less processing and retains more of its original nutrients.

Moisture Content

Moisture content was measured for both samples where 14.84% was reported in sample 01 and 14.73% in sample 02 (Table 9). Both samples exhibited a relatively high moisture content, which is typical for freshly milled rice. The moisture content of sample 01 was slightly higher than that of sample 02.

Fiber and Fat Content

Table 10 & 11 elaborate the fiber and fat content in both rice samples. Fat content in sample was recorded 0.42% followed by fiber content that was 0.37%. Whereas in sample 2 the fat content observed was 0.54% and fiber content was recorded 0.81%, respectively. Sample 02 had a higher fat content and fiber percentage as compared to sample 01.

The physical characteristics of both rice varieties indicate distinct differences. Sample 01 exhibited a higher length and thickness, while sample 02 demonstrated a higher breadth. These differences in size could affect the cooking properties and texture of the rice. The higher L/B ratio and Q. Index in Sample 01 suggest that it has better grain quality. Alkali spreading results showed that Sample 01 had a lower gelatinization temperature, making it suitable for applications requiring faster cooking. On the other hand, sample 02's higher gelatinization temperature might make it more suitable for certain types of rice products. Amylose content plays a significant role in determining the texture and cooking properties of rice. Sample 01 had a higher amylose content, which is typically associated with firmer, less sticky rice. Sample 02, with a lower amylose content, is likely to result in a softer and stickier texture when cooked.

The gel consistency tests confirmed the soft nature of both rice samples, consistent with their amylose contents. Ash and moisture content results suggest that both rice varieties are of similar quality in terms of mineral content and moisture levels. The fat and fiber content in Sample 02 were slightly higher, indicating a more fibrous texture and potentially higher nutritional value. Sensory testing indicated that both rice varieties performed similarly to commercial rice in terms of aroma, taste, and texture. No significant differences were observed in the overall acceptability when compared to the commercial rice sample.

Conclusion

This study highlights the significant differences in the quality characteristics of two rice varieties, GQTL 1401 Sample01 and Sample02. The physical, chemical, and cooking properties of these samples were analyzed, providing insights into their suitability for different culinary applications. Sample 01, with its higher amylose content, firmer texture, and stronger aroma, may be preferred for pilaf-style dishes, whereas the sample 02, with its slightly higher moisture and stickier texture, could be more suitable for dishes like sushi. The findings of this study contribute to the broader understanding of rice quality, supporting efforts to improve rice cultivation, processing, and nutritional value. Both Code;1401, sample 01 and sample 02 exhibit desirable physical and chemical properties. While Sample 01 has superior length, thickness, and amylose content, Sample 02 shows a higher fat and fiber content. Sensory evaluations indicated no significant difference in overall acceptability when compared to commercial rice, suggesting that both rice varieties have commercial potential. Further studies on large-scale cooking and consumer preferences could provide more insights into their practical applications.

Conflict of Interest: No potential conflict of interest is declared by any author.

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