INTERNATIONAL JOURNAL OF RESEARCH CULTURE SOCIETY ISSN(O): 2456-6683
Monthly Peer-Reviewed, Refereed, Indexed Journal [Impact Factor: 9.241]
Volume - 10, Issue - 5, May - 2026

DOIs:10.2017/IJRCS/202605015 --:-- Research Paper / Article / Review

Amylose content and grain phenotypic traits of rice (*Oryza sativa L.*) varieties

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Abstract: *Rice (Oryza sativa L.) quality is largely determined by physicochemical and phenotypic properties, particularly amylose content and grain morphology. In this study, amylose content and grain phenotypic traits were assessed in 36 varieties collected from both traditional and modern agricultural practices in Andhra Pradesh, India. Amylose content was determined using a standard iodine colourimetric method, while qualitative parameters such as whole-grain size, shape, pericarp colour, and 100-grain weight were evaluated in accordance with IRRI guidelines. Amylose content ranged from 7.37% to 30.50%, classifying varieties into very low, low, intermediate, and high amylose groups. Significant variation was observed in grain weight (1.12–2.74 g), size, and shape, with most varieties exhibiting medium- to slender-grained characteristics. Pigmented varieties exhibited distinct phenotypic diversity and tended to fall within the lower- to intermediate-amylose categories. The results highlight substantial diversity among rice varieties, indicating their potential for breeding programmes targeting nutritional quality and consumer preferences.*

Key Words: *Oryza sativa L., Amylose content, Phenotypic traits, Pigmented rice.*

1. INTRODUCTION:

Rice (*Oryza sativa L.*) is a staple food grain for the majority of the global population, particularly in Asian countries, and a primary source of dietary energy (Govindaraj *et al.,* 2015). Grain quality, including cooking, eating, and nutritional characteristics, plays a crucial role in shaping consumer preferences and market value. Amylose and amylopectin are the major components of rice starch. Among the physicochemical properties, amylose content is a key determinant of cooking quality, influencing texture, stickiness, and glycaemic response. Cooked rice that is soft and glossy indicates low amylose levels, whereas grains that cook dry, fluffy, and separate indicate high amylose levels (Abeysekera *et al.,* 2017).

Grain phenotypic traits such as size, shape, weight, and pericarp colour are key quality traits that strongly influence market value and consumer preferences (Lenaerts *et al*., 2019; Qaim, 2020). Traditional pigmented rice varieties are known for their rich nutritional profile, including higher levels of bioactive compounds, minerals, resistant starch, and dietary fibre (Sulochana *et al.,* 2016).

India has a rich diversity of more than 2 lakh rice varieties. Traditional varieties offer a pool of desirable traits, including high yield, high nutritional and medicinal value, and extreme stress tolerance (Pushpam *et al.,* 2019). Despite the availability of numerous traditional and improved rice varieties, integrated studies combining physicochemical and phenotypic traits remain limited.

2. AIM: The present study aimed to evaluate amylose content and grain phenotypic characteristics of rice varieties and to assess their variability and potential significance.

3. RESEARCH METHODOLOGY:

3.1 Plant material

A total of 36 rice varieties, comprising 26 traditional and 10 improved varieties, were collected from organic farmers across the coastal districts of Andhra Pradesh and from the Andhra Pradesh State Seeds Development Corporation Ltd (APSSDC), Vijayawada, India.

3.2 Determination of amylose content

Amylose content was determined by the iodine colourimetric method described by Juliano (1971). Dehulled rice grains were ground to a powder, and 100 mg of each sample was treated with 1 ml of 95% ethanol and 9 ml of 1 N sodium hydroxide (NaOH), then heated for 10 minutes in a boiling water bath to gelatinise the starch. The samples were allowed to cool, and the volume was adjusted to 100 ml. 5 ml of the sample solution was transferred to a 100 ml volumetric flask, and 1 ml of 1 N acetic acid and 2 ml of 0.2% iodine solution were added. The volume was adjusted to 100 ml, and the flask was shaken and allowed to stand for 20 minutes at room temperature. After dilution and reaction with iodine solution, absorbance was measured at 620 nm using a UV spectrophotometer. The amylose content was calculated using a standard prepared from potato starch.

3.3 Phenotypic characterization

Grain phenotypic traits were evaluated in accordance with IRRI standard guidelines (Rabara *et al.*, 2014). Grain length and width were measured on 10 randomly selected grains, and the length-to-width (L/W) ratio was calculated. Grain size was categorised as extra-long (>7.50 mm), long (6.61 to 7.50 mm), medium (5.51 to 6.60 mm), or short (<5.50 mm). Grain shape was characterised based on the length-to-width ratio: slender (>3.0); medium (2.1 to 3.0); bold (1.1 to 2.0); round (<1.0). The 100-grain weight was measured using a digital balance, and pericarp colour was recorded visually.

3.4 Statistical Analysis

All measurements were performed in triplicate, and the data are expressed as the mean ± SE (n=10 per group). Significant differences were observed in the length and width of husked and dehulled rice grains.

4. RESULTS:

4.1Amylose content variation

Amylose content (Table 1) across the studied rice varieties ranged from 7.37% to 30.28%, indicating substantial variability. Based on the standard classification (Juliano, 1971), rice varieties were grouped into waxy (0-2%), very low (5-12%), low (12-20%), intermediate (20-25%), and high (25-33%) amylose categories. Most traditional black- and red-pigmented varieties exhibited very low to low amylose levels, whereas improved and brown rice varieties predominantly fell into the intermediate- and high-amylose categories.

Table 1. Estimated amylose content in rice varieties

Variety	Amylose content %	Amylose class	Variety	Amylose content %	Amylose class
1. Kalabath	7.373±0.08	VLA	19. Mappillai samba	24.312±0.30	IA
2. Kalabatti	8.042±0.24	VLA	20. ADT 37	24.447±0.89	IA
3. China black	8.825±0.04	VLA	21. NLR-34449	24.513±0.11	IA
4. Kalabattu	10.766±0.18	VLA	22. Mysore Malliga	24.660±0.09	IA
5. Burma black	12.949±0.71	LA	23. Kamal Shankari	24.662±0.16	IA
6. Krishna lohi	16.677±0.60	LA	24. RNR-15048	24.723±0.10	IA
7. Thiwan black	17.040±0.41	LA	25. Siddha sannalu	24.734±0.05	IA
8. Ratna choodi	17.254±0.45	LA	26. MTU-1153	25.324±0.17	HA
9. Black rice	17.498±0.01	LA	27. Kulakar rice	25.108±0.41	HA
10. MTU-3626	18.851±0.14	LA	28. Chitti Muthyalu	25.515±0.07	HA
11. Bahurupi	19.159±0.05	LA	29. Khetri Maharaj	25.823±0.50	HA
12. Kudarat 15	19.246±0.36	LA	30. MTU-1061	26.025±0.88	HA
13. MTU-1121	20.605±0.18	IA	31. HMT	26.063±1.28	HA
14. MTU-1156	21.248±0.50	IA	32. Chintaluri Sannalu	26.649±0.40	HA
15. Philippine rice	21.426±0.44	IA	33. MTU-7029	27.093±0.70	HA
16. Nasara batta	21.949±0.77	IA	34. Kujupatali	27.522±0.29	HA
17. BPT-5204	22.509±0.12	IA	35. Njavara Black	29.414±0.12	HA
18. Dudeswar	24.154±0.60	IA	36. Njavara yellow	30.286±0.13	HA

VLA: Very Low Amylose; LA: Low Amylose; IA: Intermediate; HA: High Amylose

4.2 Phenotypic Characterisation of Traditional Rice Varieties

Traditional varieties (Figure 1) were collected based on health claims in traditional knowledge and associated findings. The International Rice Research Institute (IRRI) classification system was used to evaluate whole-grain weight, rice size and shape, and pericarp colour (Rabara *et al*., 2014).

The varieties showed significant variation across parameters (Table 2). H: L (High: Low) values for 100-grain weight were observed in MTU-3626 (2.74±0.012 g) and Dudeswar (1.12±0.010 g), which are long, medium, and medium-slender grains. Grain weight is an important yield and quality parameter, influenced by both genetic and environmental factors. The grain length of the rice varieties varied widely. The H: L value of length was observed in Black rice (7.5±0.16 mm) and Chitti muthyalu (3.98±0.01 mm), which are extra-long and short grains. Based on grain size classification, most varieties were categorised as medium- or long-grains. H: L values of width were observed in Bahurupi, MTU-3626 (2.55±0.05 mm), and Dudeswar (1.1±0.04 mm), which are short-medium, long-medium, and medium-slender grains. The grain shape (L/W ratio) indicated that most varieties were slender, followed by medium and bold types. H: L values of the L: W (Length: Width) ratio were observed in Dudeswar (5.36±0.00 mm) and Chitti muthyalu (1.89±0.00 mm), which are medium-slender and short-bold grains. Grain morphology is a key determinant of consumer preference, with long, slender grains generally preferred across many regions. The diversity in grain size and shape reflects the genetic variability within traditional rice germplasm.

4.3 Pericarp colour

The pericarp colour (Figure 1) of the rice varieties includes black, red, white, or brown. Nine varieties, including Burma black, Black rice, China black, Kala bhaat, Kala batti, Krishna lohi, Kaala battu, and Taiwan black, had black pericarps of varying intensity. Four varieties (Kulakar rice, Mapillai samba, Njavara yellow, and Njavara black) had red pericarps, while the remaining varieties had semi-brown or white pericarps. Pigmented varieties are known for their higher nutritional and antioxidant properties due to bioactive compounds.

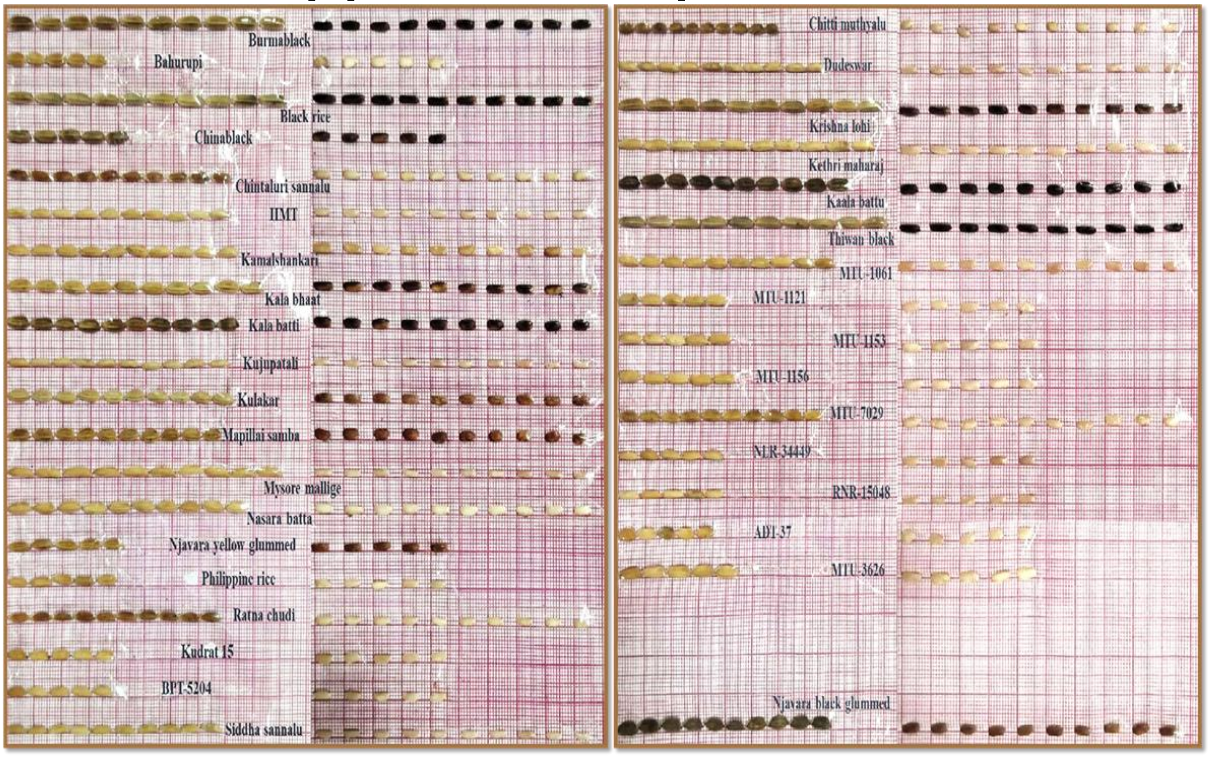

Figure 1. Whole-grain phenotype and pericarp colour of rice varieties. Length and width were measured in millimetres with a ruler, and the mean was calculated.

Table 2: Phenotypic properties of the collected rice varieties.

S. No.	Variety Name	Length (mm)	Width (mm)	L: W Ratio (mm)	Grain size	Grain shape	Pericarp colour	100 grains weight (g)
1	Chitti muthyalu	3.98±0.01	2.1±0.04	1.89	Short	Bold	White	1.17±0.005
2	ADT-37	5.1±0.06	2.52±0.02	2.01	Short	Bold	White	2.16±0.011
3	RNR-15048	5.45±0.05	1.45±0.05	3.74	Short	Slender	White	1.39±0.013
4	MTU-7029	5.45±0.05	2.05±0.05	2.65	Short	Medium	White	2.20±0.017
5	Mapillai samba	5.45±0.08	2.8±0.08	1.94	Short	Bold	Red	2.72±0.013
6	Bahurupi	5.50±0.07	2.55±0.05	2.15	Short	Medium	White	2.16±0.015

7	Kujupatali	5.65±0.11	1.45±0.03	3.89	Medium	Slender	White	1.26±0.008
8	Ratna choodi	5.8±0.08	1.95±0.03	2.97	Medium	Medium	White	1.74±0.042
9	HMT	5.85±0.07	1.97±0.02	2.96	Medium	Medium	White	1.55±0.004
10	NLR-34449	5.85±0.07	1.47±0.02	3.96	Medium	Slender	White	1.60±0.005
11	Philippine rice	5.9±0.01	1.96±0.02	3.01	Medium	Medium	White	1.65±0.018
12	Njavara black	5.9±0.06	2.25±0.08	2.62	Medium	Medium	Red	2.28±0.007
13	Kaala battu	5.9±0.06	2.2±0.08	2.68	Medium	Medium	Black	2.29±0.004
14	Dudeswar	5.9±0.10	1.1±0.04	5.36	Medium	Slender	White	1.12±0.010
15	Siddha sannalu	5.9±0.10	1.8±0.03	3.27	Medium	Slender	White	1.44±0.015
16	Mysore mallige	5.92±0.03	1.88±0.04	3.16	Medium	Slender	White	1.57±0.004
17	Chintaluri sannalu	5.96±0.02	1.96±0.02	3.04	Medium	Medium	White	1.70±0.004
18	Kulakar rice	5.96±0.01	1.97±0.02	3.02	Medium	Medium	Red	2.47±0.025
19	Kudarat-15	5.97±0.02	1.98±0.01	3.02	Medium	Medium	White	1.66±0.012
20	BPT-5204	5.99±0.01	1.9±0.04	3.15	Medium	Slender	White	2.04±0.006
21	MTU-1061	6.01±0.01	1.95±0.05	3.08	Medium	Slender	White	2.08±0.015
22	China black	6.1±0.01	1.98±0.02	3.08	Medium	Slender	Black	2.26±0.01
23	Kala batti	6.1±0.06	2.45±0.05	2.48	Medium	Medium	Black	2.51±0.023
24	MTU-1121	6.15±0.07	1.99±0.01	3.09	Medium	Slender	White	2.16±0.006
25	Njavara yellow	6.2±0.08	1.98±0.01	3.13	Medium	Slender	Red	2.39±0.008
26	Nasara batta	6.3±0.08	2.3±0.08	2.73	Medium	Medium	White	2.69±0.014
27	MTU-1153	6.60±0.06	1.99±0.01	3.31	Medium	Slender	White	2.59±0.012
28	Burma black	6.7±0.08	1.97±0.02	3.36	Long	Slender	Black	2.5±0.022
29	Krishna lohi	6.75±0.13	1.75±0.08	3.85	Long	Slender	Black	2.30±0.012
30	MTU-3626	6.8±0.08	2.55±0.05	2.66	Long	Medium	White	2.74±0.012
31	MTU-1156	6.8±0.08	1.98±0.02	3.43	Long	Slender	White	2.64±0.011
32	Kamalshankar	6.8±0.08	1.96±0.03	3.47	Long	Slender	White	2.52±0.021
33	Taiwan black	6.97±0.01	1.85±0.04	3.76	Long	Slender	Black	2.22±0.016
34	Kala bhaat	6.97±0.02	1.99±0.01	3.50	Long	Slender	Black	2.37±0.010
35	Kethri Maharaj	6.98±0.01	1.95±0.03	3.57	Long	Slender	White	2.23±0.005
36	Black rice	7.5±0.16	1.99±0.03	3.76	Extra long	Slender	Black	2.55±0.017

5. DISCUSSION :

Previous research has highlighted the potential health benefits of coloured or pigmented traditional rice varieties. Consumer preferences for grain size and shape vary, with long, slender grains generally preferred in Southeast Asia. However, some traditional varieties, such as the short, bold Mappillai samba, are preferred in southern India for their nutritional and functional properties (Thanuja & Parimalavalli, 2018; Tonlong *et al*., 2019; Priya *et al*., 2019). This study demonstrates the phenotypic diversity of traditional rice varieties, underscoring the need for further exploration of their potential health benefits and nutritional value.

Grain length and the length-to-width (L/W) ratio were positively associated, indicating that longer grains tend to be more slender. Grain width was inversely related to the L/W ratio, confirming that wider grains are generally broader. Amylose content showed a weak association with grain size and weight, suggesting that physicochemical properties are largely independent of external grain morphology. However, pigmented rice varieties tended to cluster within the low- to intermediate-amylose groups, suggesting a possible nutritional link. Significant variation in amylose content and phenotypic traits was observed among rice varieties, indicating substantial genetic diversity.

6. CONCLUSION:

In conclusion, the present study revealed significant diversity in amylose content and grain phenotypic traits across traditional and improved rice varieties. Traditional pigmented rice varieties exhibited greater diversity and favourable nutritional attributes, including lower amylose content. These variations have important implications for consumer acceptance, nutritional value, and potential health benefits. The study findings underscore the importance of conserving and exploring traditional rice varieties, which can serve as a valuable genetic resource for future breeding programmes and contribute to improved food security and human health.

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