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## Research Note

# Impact of starch profile on glycemic index of coloured and non-pigmented genotypes of rice (*Oryza sativa* L.)

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**Abstract**
Rice serves as a crucial staple food, supplying energy and nutrients to roughly half the global population. Consumers prefer to take mostly the white rice, but pigmented rice is enriched with anthocyanin and has potential health benefits. The study of 27 rice genotypes consisting of eight non-pigmented and 19 pigmented genotypes were estimated for protein content, antioxidant activity and starch profile including total starch(TS), Resistant Starch(RS), Slowly Digestible Starch(SDS), Rapidly Digestible Starch(RDS), Amylose content(AC), and Glycemic Index (GI). This study shows that RS and SDS levels have a negative correlation with GI, whereas RDS has a positive association with the glycemic index. The starch content and amylose content were not showing any direct relation with the GI. There was minimal variation in the glycemic index between pigmented and non-pigmented rice varieties.

**Keywords:** Antioxidant activity, glycemic index, pigmented rice, resistant starch, slowly digestible starch, starch profile

Among the cereals, rice crop is the most widely preferred in Asian countries and India is recognized as the second largest country in production of rice. Several studies conducted around the globe summarize the increased threat of diabetes (type II) among rice consumers. Among different starch sources, rice grain possess high glycemic index (GI) (Meera*et al*., 2019). Dietary starches can be divided into three fractions *viz.,* Rapidly Digestible Starch(RDS), Slowly Digestible Starch(SDS) and Resistant Starch (RS)depending on the digestion time when incubated with enzymes. RDS hydrolyzes into glucose within 20 minutes of enzymatic action while SDS is converted into glucose between 20 and 120 minutes of enzyme interaction. whereas RS remains undigested even after 120 minutes ( Englyst*et al*., 1992). In the small intestine, the RDS causes a major spike in the glucose level of blood after eating and during digestion, whereas the SDS digests slowly while the resistant starch escapes digestion in the small intestine and reaches the large intestine where it is fermented and act as a probiotic. Thus, the relative proportions of RDS, SDS, and RS of the food material decide the value of GI and the food with lower GI manages the fluctuations in glucose levels of blood (Fuentes-Zaragoza *et al.,* 2010). Large quantity of dietary fiber components including non-starchy polysaccharides and RS are present in whole grains which are a healthy option for daily diet. Recently, interest is growing among consumers for foods possessing healthier carbohydrates possessing low GI. Because of higher bioactive compounds, rice varieties possessing different pericarp colours are being received attention around the world in the recent past. Consumers also preferring different colored rice varieties because of their health benefits such as anti-inflammatory, anti-oxidants etc., (Alves *etal.,*2016). In this study, we assessed the biochemical parameters, physico-chemical quality, and nutritional characteristics of 27 pigmented and non-pigmented rice genotypes. Our goal was to identify genotypes that offer both high nutraceutical value and a low glycemic index. The starch profile of these genotypes also estimated to realize the impact of SDS and RS on glycemic index.

In this research, we cultivated 27 advanced and released rice varieties (*Oryza sativa* L.) during the Kharif season of 2021 at the Agricultural Research Station in Bapatla, Andhra Pradesh, India. These varieties included eight non-pigmented genotypes (BPT 2270, BPT 5204, BPT 2782, BPT 2295, BPT 2595, BPT 2766, BPT 2660, and BPT 2776), nine red pericarp-colored genotypes (Annapurna, Aanthra, Jyothi, Samyuktha, MattaTriveni, BPT 3111, BPT 3269, Harsha, and BPT 2858), and ten black pericarp-colored genotypes (BPT 2841, BPT 3136, BPT 3149, BPT 3140, BPT 3137, BPT 3141, BPT 3145, BPT 3143, BPT 3154, and BPT 2848). Of these 27 genotypes, 11 were released varieties while 16 were advanced cultures developed at the same research station. Twenty five days old nurseries of each genotype were transplanted into main field consisting of five rows, each three meters length, using a Randomized Block Design (RBD) replicated three times. The planting spacing was set at 20 x 15 cm, and maintained healthy crop by adhering to optimal agricultural practices. Data on days to flowering and test weight were recorded on a per-plot basis, while yield was computed from five plants in each replication to assess the average yield per plant. Following harvest, paddy samples from each treatment/replication, containing 12% moisture content, were analyzed. Unpolished rice samples were ground to powder and was used for the analysis of 11 parameters, including physicochemical properties, nutritional content, antioxidant levels, and starch profiles, all performed in triplicate. The grain type, ASV, and AC(&) were determined as per the procedures outlined in IIRR, 2006. The Anthrone method (Hodge and Hofrieter, 1962) was used for analysis of total starch content, while the Lowry *et al.,* (1951) procedure was followed for protein estimation. The DPPH radical scavenging activity, indicative of total antioxidant activity(AoA), was estimated using the method developed by Pathirana and Shahidi (2005) and expressed as mg AAE/100g of the sample. Additionally, an invitro method, refined from the approach by Goni*et al*., (1997) and standardized at PHTC, Bapatla, was employed to assess the Glycemic Index (GI) and Resistant Starch levels.

To replicate the conditions of the human small intestine, we utilized a dialysis tube (Hi Media, Mumbai, India) with dimensions of 24.26 mm in width and 14.3 mm in diameter for our analysis. For each treatment,0.20 g test sample was kept in a tube, added 2 mL of distilled water and heated for 2 minutes. Subsequently, 5mLof 0.1 M phosphate buffer (pH 6.9) from MP Biomedicals (Santa Ana, CA) was added, and the tube was vigorously shaken. The pH was then adjusted to 2.5 using 10% phosphoric acid (Merck, Darmstadt, Germany). Pepsin (200 µL at 250 mg/mL concentration; (MP Biomedicals, Santa Ana, CA) was introduced into the tube, which was then incubated in a water bath shaker (RSB-12; REMI Sales & Engineering, Ltd, Mumbai, India) at 37°C and 110 rpm for 60 minutes. Following this, the pH was normalized to 6.9 with 20% potassium hydroxide (MP Biomedicals), and then 200 µL of α-amylase (125 mg/mL; MP Biomedicals) was added. The mixture was promptly transferred to a dialysis tube and was keptin a 100 mL beaker with 40 mL of phosphate buffer (0.1 M, pH 6.9) and incubated at 37°C and 110 rpm. At 30-minute intervals up to 3 hours, 500 µL aliquots were extracted, mixed with 1.5 mL of 0.4 M sodium acetate buffer (pH 4.75; MP Biomedicals), and treated with 30 µL of AMG amyloglucosidase (3300 U/mL; Megazyme International Ltd, Bray, Ireland) at 50°C for 30 minutes. After that, it was diluted with distilled water to 10 mL, 0.3mL aliquots (in triplicate) were reacted with 3 mL of GOPOD reagent (glucose oxidase/peroxidase; Megazyme International Ltd) and incubated for a period of 20 minutes at 50°C. Glucose release was monitored, and the absorbance reading was taken at 510 nm using a Model 4001/A spectrophotometer (Thermo Spectronic, Thermo, Waltham, MA). Standard carbohydrate measurements were conducted similarly using D-glucose (0.2 g; MP Biomedicals, USA). Glucose liberation data from the three replicates were plotted over time, and the area under the curve (AUC) was determined for both rice and standard glucose samples. The Hypoglycemic Index (HI) for each rice variety was computed by comparision of the AUC of the sample to that of glucose and was expressed as a percentage. The Predicted Glycemic Index (PGI) value was estimated using the formula by Goni *et al.,* (1997), while the methods described by Englyst *et al.,* (1999) were employed to estimate the Rapidly Digestible Starch (RDS) and Slowly Digestible Starch (SDS).

Statistical analysis: The average of the data collected for various parameters were analyzed using the statistical package SAS 9.2 software. The mean value of each parameter, determined from triplicate measurements, were presented as Mean ± SD. Two-way analysis of variance (ANOVA) was employed to compare treatments, with statistical significance set at $p<0.01$. Genetic parameter estimates were computed using Microsoft Excel, and Pearson's correlation coefficient was utilized to determine both genotypic and phenotypic correlation coefficients, with significance reported at $p<0.01$.

The two-way ANOVA analysis results revealed significant differences among the genotypes for all the studied characters. Genetic variances, indicative of gene action, were evaluated across various traits. The variances for both phenotypic and genotypic coefficients were highest for antioxidant activity, with values of 35.29 and 34.9, respectively, while protein content (%) displayed the lowest estimates at 6.72 and 6.21 (**Table 1**). Heritability estimates across traits ranged from 87.9% for yield/plant to 99.5% for total antioxidant activity. The percentage of genetic advance relative to the mean varied from 15.38% for rapidly digestible starch to 91.4% for resistant starch. Among the characters studied, total starch, amylose

**Table 1. Genetic parameters for grain yield, nutritional and biochemical quality parameters in pigmented and non-pigmented rice (*Oryza sativa* L.) genotypes**

| S. No. | Character | Mean | Phenotypic coefficient of variation (%) | Genotypic coefficient of variation (%) | Heritability (%) | Genetic advance as per cent of mean |
|---|---|---|---|---|---|---|
| 1 | Protein content (%) | 9.94 | 6.72 | 6.21 | 96.8 | 42.3 |
| 2 | Amylose content(%) | 22.66 | 12.34 | 12.02 | 94.3 | 21.89 |
| 3 | Total Starch Content (%) | 70.31 | 12.98 | 12.69 | 98.9 | 27.34 |
| 4 | Rapidly Digestible Starch (%) | 61.16 | 8.70 | 8.63 | 99.4 | 15.38 |
| 5 | Slowly Digestible Starch (%) | 36.42 | 14.90 | 14.71 | 94.8 | 22.6 |
| 6 | Resistant Starch (%) | 2.31 | 7.37 | 7.02 | 96.9 | 91.4 |
| 7 | Total Antioxidant Activity (mg AAE/100 g) | 80.27 | 35.29 | 34.9 | 99.5 | 67.9 |
| 8 | Glycemic Index | 60.57 | 8.42 | 8.27 | 95.6 | 18.5 |
| 9 | Grain yield/plant (g) | 40.69 | 16.74 | 16.32 | 87.9 | 29.8 |

content, slowly digestible starch, alkali spreading value, total antioxidant activity, and grain yield/plant manifested high genetic coefficients of variation, phenotypic variation, heritability, and genetic advance, indicating an additive gene effect. Understanding the genetic action underlying inheritance patterns is crucial for population improvement and selecting appropriate breeding strategies. Additive genetic variance is useful to achieve genetic gains. The study suggests that the above mentioned characters could be improved by following selection methods, aligning with previous research by Patil *et al.,* (2015), Devi *et al.,* (2016), Samak *et al*., (2015), Ali *et al.,* (2018) and Usha *et al* (2022). Conversely, traits such as protein content (%), rapidly digestible starch (%), resistant starch (%), and glycemic index exhibited low to moderate coefficients of variation, high heritability, and variable genetic advance, suggesting a combination of both additive and non-additive gene action in controlling these traits. While both additive and non-additive gene actions influence polygenic traits, additive effects predominantly determine their expression.

The average data for biochemical, physico-chemical and nutritional parameters of 27 rice genotypes along with grain yield/plant are represented in **table 2**. Majority of the genotypes under study, had medium slender grain, the most favored grain type in Southern states of India. Among red pericarp coloured genotypes, MattaTriveni, Aathira, Annapurna and Harsha recorded short bold (SB) grain types,while two genotypes *viz.*, BPT 3136 BPT 3145 possess long bold grain with black pericarp colour. BPT 2766 (49.21g) manifested maximum grain yield followed by BPT 2782 (47.7 g) and BPT 2776 (40.33g) among the studied non-pigmented rice varieties. MattaTriveni (45.33g) recorded high grain yield among red pericarp coloured varieties, whereas BPT 3154 (50.33g) had maximum single plant yield among black pericarp coloured rice genotypes. The cooked rice texture is majorly determined by alkali spreadingvalue (ASV) along with amylose (AC)content of the rice sample. The AC influences the organoleptic traits of rice after cooking and has also culinary implications (Li *et al.,* 2016). Among the brown pericarp coloured non- pigmented rice genotypes, six varieties *viz.*, BPT 2782, BPT 2270, BPT 5204, BPT 2776, BPT 2595 and BPT 2766 recorded intermediate AC and ASV which plays a major role in determining the cooked rice flaky texture and softness. Intermediate amylose and ASV were recorded by BPT 2858, BPT 3111, BPT 3269, in red pericarp coloured varieties and BPT 2841, BPT 3136, BPT 3140, BPT 2848 among black rice, which is very much desirable for getting flaky and smooth texture to rice after cooking. Majority of popular black rice varieties/land races grown in North India possess bold grain and low amylose content. Kumar *et al*., (2018) also reported that the popular glutinous desi black rice variety Burma black has low amylose content (4.27%). South Indian rice consumers don't prefer bolder grain and glutinous texture of rice after cooking. In the present study, five black rice genotypes *viz.,* BPT 2848, amylase content & alkali spreading value and high anti-oxidant activity. Hence, these genotypes can be added in daily diet because of their potential health and nutraceutical benefits.

Among the 27 genotypes tested, RDS was minimum in BPT 2848 (49.75%) and maximum in BPT 3140 (67.55%) whereas SDS varied from 30.28 (BPT 3143) to 46.28 (BPT 2848). in the small intestine, RDS, and SDS also completely digests but SDS digests more slowly hence, SDS is linked to it's positive health benefits like stable glucose metabolism, diabetes management and satiety (Lehmann and Robin, 2007). Hence, rice possessing more SDS values will have low GI and are desirable for inclusion in a diabetic diet. Among non-pigmented rice, BPT 2270 (42.84%), BPT 5204 (41.02%) and BPT 2660 (41.14%) recorded high SDS. Jyothi (1.1%), a red rice variety popular in the state of Kerala recorded minimum RS content while BPT 2848 (3.97%) recorded maximum RS along with BPT 2858 (3.59%),BPT 3111 (3.52%), BPT 3145 (3.41%) and BPT 2595 (3.21%) which is a desirable

**Table 2. Yield performance, nutritional, biochemical properties, glycemic index and starch profile of different pigmented and non-pigmented rice genotypes (*Oryza sativaL)***

| S. No. | Designatiion | Grain type | Alkali spreading value | Amylose content (%) | Total Starch content(%) | Rapidly Digestible Starch (%) | Slowly Digestible Starch (%) | Resistant Starch (%) | Glycemic Index | Anti-oxidant activity(mg AAE/100g) | Protein content (%) | Grain yield/ plant (g) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Brown pericarp colored genotypes** | | | | | | | | | | | |
| 1 | BPT 5204 | MS | 5.00±0.00 | 22.65±1.32 | 65.39±0.90 | 56.53±0.44 | 41.02±0.16 | 2.45±0.09 | 54.44±1.08 | 28.39±0.33 | 8.00±0.56 | 25.00±3.60 |
| 2 | BPT 2660 | MS | 3.87±1.52 | 21.11±1.28 | 64.16±0.32 | 56.62±0.25 | 41.14±0.45 | 2.24±0.05 | 54.18±1.05 | 46.67±0.24 | 9.03±0.18 | 36.67±2.08 |
| 3 | BPT 2295 | MS | 3.63±0.28 | 25.45±0.87 | 63.88±0.35 | 58.49±0.27 | 38.67±0.25 | 2.84±0.03 | 56.64±1.4 | 26.87±0.11 | 7.11±0.16 | 33.33±4.16 |
| 4 | BPT 2776 | MS | 4.00±1.73 | 23.55±0.74 | 70.80±0.15 | 65.97±0.26 | 32.85±0.28 | 1.18±0.07 | 68.00±1.7 | 30.72±0.30 | 6.23±0.13 | 40.33±5.13 |
| 5 | BPT 2782 | MS | 4.54±0.28 | 21.45±0.91 | 63.41±0.37 | 60.69±0.20 | 37.05±0.41 | 2.26±0.02 | 59.04±1.49 | 44.90±0.33 | 7.14±0.12 | 47.70±1.34 |
| 6 | BPT 2270 | MS | 4.33±0.28 | 20.98±0.54 | 62.78±0.19 | 54.59±1.39 | 42.84±0.68 | 2.57±0.04 | 53.26±1.46 | 29.94±0.30 | 9.14±0.12 | 29.33±5.13 |
| 7 | BPT 2595 | MS | 4.67±0.28 | 23.97±0.20 | 62.52±0.35 | 64.46±0.33 | 32.33±0.28 | 3.21±0.04 | 60.08±0.32 | 28.31±0.46 | 9.21±0.2 | 37.00±2.64 |
| 8 | BPT 2766 | MS | 4.21±0.32 | 23.31±0.42 | 66.50±0.54 | 61.56±0.33 | 35.53±0.28 | 2.91±0.04 | 59.40±0.32 | 38.31±0.54 | 8.7±0.42 | 49.21±0..64 |
| | **Red pericarp colored genotypes** | | | | | | | | | | | |
| 1 | MathaTriveni | SB | 2.00±0.0 | 27.44±0.45 | 78.53±0.19 | 63.88±0.87 | 34.91±0.36 | 1.21±0.02 | 60.71±1.22 | 106.44±0.43 | 10.54±0.12 | 45.33±2.91 |
| 2 | Annapurna | SB | 3.00±0.0 | 18.86±0.64 | 74.74±0.25 | 61.74±0.22 | 36.94±0.24 | 1.32±0.05 | 69.07±0.8 | 107.75±0.39 | 9.13±0.19 | 44.43±4.53 |
| 3 | Aathira | SB | 2.00±0.0 | 24.24±1.14 | 86.37±0.15 | 58.48±0.21 | 39.40±0.46 | 2.12±0.02 | 57.12±0.29 | 105.13±0.34 | 8.25±0.12 | 35.13±1.58 |
| 4 | Harsha | SB | 2.00±0.0 | 25.37±0.76 | 78.41±0.31 | 60.59±0.17 | 37.35±0.12 | 2.06±0.03 | 72.0±0.64 | 106.67±0.18 | 9.44±0.08 | 42.53±1.68 |
| 5 | Jyothi | MS | 2.00±0..0 | 22.0±0.13 | 68.72±0.25 | 64.59±0.27 | 34.31±0.52 | 1.10±0.25 | 66.00±1.68 | 111.48±0.28 | 10.48±0.25 | 44.00±1.0 |
| 6 | Samyuktha | MS | 2.00±0.0 | 26.36±0.69 | 70.85±0.37 | 62.77±0.19 | 34.34±0.43 | 2.89±0.2 | 59.10±0.77 | 100.91±0.17 | 9.07±0.1 | 42.67±4.83 |
| 7 | BPT 2858 | SS | 4.33±0.32 | 21.18±0.38 | 61.26±0.31 | 51.32±0.17 | 39.79±0.55 | 2.89±0.11 | 57.92±0.39 | 105.83±0.14 | 12.82±0.11 | 41.73±3.33 |
| 8 | BPT 3111 | MS | 4.23±0.54 | 23.02±0.46 | 66.97±0.14 | 64.20±0.27 | 32.28±0.41 | 3.52±0.07 | 58.12±0.63 | 110.09±0.18 | 10.97±1.3 | 42.13±0.41 |
| 9 | BPT 3269 | MS | 4.03±0.28 | 22.6±0.48 | 86.95±0.29 | 61.50±0.56 | 36.15±0.78 | 2.35±0.08 | 60.13±0.46 | 109.53±0.74 | 9.41±0.22 | 36.89±3.1 |
| | **Black pericarp colored genotypes** | | | | | | | | | | | |
| 1 | BPT 2841 | MS | 4.00±0.50 | 22.36±0.45 | 61.19±0.28 | 60.79±1.15 | 36.32±0.42 | 2.89±0.38 | 60.99±0.29 | 110.50±0.61 | 11.52±0.17 | 43.93±3.70 |
| 2 | BPT 2848 | MS | 4.57±0.87 | 20.88±0.90 | 74.49±0.16 | 49.75±0.32 | 46.28±0.42 | 3.97±0.49 | 49.50±0.21 | 86.63±0.65 | 13.41±0.36 | 40.70±0.95 |
| 3 | BPT 3136 | LB | 4.17±0.57 | 21.12±0.74 | 84.86±0.21 | 65.03±0.42 | 32.43±0.33 | 2.54±0.12 | 59.40±0.28 | 78.55±0.21 | 13.55±0.73 | 48.83±4.35 |
| 4 | BPT 3137 | MS | 4.00±0.61 | 21.41±0.84 | 78.53±0.53 | 60.59±0.17 | 38.16±0.56 | 1.25±0.04 | 62.71±0.45 | 91.05±0.42 | 8.26±0.13 | 35.93±1.10 |
| 5 | BPT 3145 | LB | 3.67±0.28 | 21.60±0.35 | 71.78±0.14 | 58.69±0.26 | 37.90±1.03 | 3.41±0.11 | 56.45±1.31 | 96.38±0.39 | 12.56±0.21 | 41.77±3.45 |
| 6 | BPT 3149 | MS | 3.00±0.50 | 24.08±0.19 | 66.61±0.9 | 59.88±0.05 | 37.18±0.29 | 2.94±0.02 | 58.90±1.05 | 84.46±0.36 | 9.59±0.16 | 38.03±0.85 |
| 7 | BPT 3140 | MS | 4.00±0.50 | 22.17±0.28 | 65.18±0.33 | 67.55±0.32 | 30.89±0.23 | 1.56±0.07 | 69.25±0.71 | 109.83±0.28 | 10.95±0.23 | 40.20±1.15 |
| 8 | BPT 3141 | MS | 3.50±0.72 | 21.67±0.78 | 67.23±0.23 | 66.03±0.34 | 32.82±0.14 | 1.15±0.12 | 70.12±0.36 | 106.57±0.26 | 12.39±0.48 | 37.63±3.29 |
| 9 | BPT 3154 | MS | 3.00±0.50 | 22.05±0.48 | 65.64±0.25 | 60.53±0.26 | 37.15±0.32 | 2.32±0.05 | 57.60±0.38 | 87.07±0.84 | 11.35±0.72 | 50.33±7.23 |
| 10 | BPT 3143 | MS | 3.17±0.28 | 21.11±0.64 | 71.11±0.21 | 68.49±0.38 | 30.28±0.21 | 1.23±0.06 | 65.20±0.73 | 78.36±0.18 | 10.45±0.06 | 48.03±6.47 |
| | Mean | - | 3.59 | 22.66 | 70.31 | 61.16 | 36.42 | 2.31 | 60.57 | 80.27 | 9.94 | 40.69 |
| | SD | - | 0.88 | 2.49 | 9.07 | 5.43 | 3.84 | 0.85 | 4.97 | 30.55 | 2.48 | 6.90 |
| | CD (0.01) | - | **0.00** | 1.48 | 0.71 | 0.98 | 0.94 | 0.20 | 2.03 | 0.01 | 2.03 | 0.01 |
| | P<0.01 | - | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.002 | 0.001 | 0.002 |

trait. Rice grain possessing low Glycemic Index coupled with less RS content aids in sustained glucose release, which reduces the response of insulin thereby manage the steady blood glucose level (Englyst *et al.,* 1992).

Samba Mahsuri, a popular mega rice variety in India which recorded low GI under *invivo* method as per the study conducted by Babu *et al*., (2014) also exhibited similar trend in *invitro* method of estimation in this study. Likewise, the varieties which possess low GI, high RS value along with excellent physico-chemical, desirable eating quality characters should be popularized among consumers which improves the quality of carbohydrate in daily diet. BPT 2848, a black rice genotype, exhibited minimum RDS (49.75%), maximum SDS (46.28%) and high resistant starch (3.97%) which resulted in the manifestation of low glycemic index value (48.50) and also possess high antioxidant activity; hence it may be suggested for inclusion in diabetic diet for realizing beneficial health effects received from bioactive compounds. Glycemic index is the classification of food depending on the blood glucose response to a food relative to the standard glucose solution which acts as a therapeutic principle for *Diabetes mellitus*. Among the material under study, the GI ranged from 49.50 (BPT 2848) to 72.10 (Harsha). The genotypes possessing low GI include BPT 2270 (53.26), BPT 5204 (54.44), BPT 2858 (54.29) and BPT 2660 (54.18). These genotypes also manifested desirable and high SDS and RS values. It is evident from the study, that the genotypes with high SDS and RS content will manifest lower GI. The inverse relationship of RDS with resistant starch was previously reported by Patindol *et al* (2010).

Among red pericarp-colored rice, Jyothi (111.48mg AAE/100g) recorded maximum anti-oxidant activity while BPT 3140 (109.83 mg AAE/100g) manifested high AOA among black pericarp-colored genotypes. The coloured rice contains 2-3 times high anti-oxidant activity when compared with the non-pigmented rice genotypes. Similar results were earlier reported by Vasantha *et al*., (2022). Protein content (PC)varied from 6.23% (BPT 2776) to 13.55% (BPT 3136) and BPT2858 (12.82%), BPT3111 (10.97%), Matha Triveni (10.54%) and Jyothi (10.48%), exhibited high PC among red pericarp-colored genotypes. Except for BPT 3137 and BPT 3149 all black pericarp-colored genotypes recorded PC of >10%. Among these, six genotypes *viz.,* BPT 2848, BPT 2858, BPT 3136, BPT 3145, BPT 3154 and BPT 3149 exhibited low to medium GI (<60.0). In glucose homeostasis, protein acts as modulator and prevents resistance to insulin (Ke *et al.,* 2018), thus, high protein rice will digest slowly in the intestine and manages in balancing the blood glucose level. Protein-rich foods increase insulin secretion leading to the lowering of postprandial blood glucose concentrations (Eleazu,2016).

Correlation of Glycemic index with starch profile: Previous research by Kumar*et al*., (2018) indicated a negative correlation between resistant starch (RS) and glycemic index (GI), emphasizing the significant role of RS in manipulating the GI value of food. Consistent with these findings, our study also demonstrated a notable negative correlation between GI and RS at phenotypic (-0.586*) and at genotypic levels (-0.602*) (**Table 3 & Fig. 1**). Furthermore, amylose content(AC) displayed a positive correlation with RS (0.330* &

**Table 3. Estimates of phenotypic (P) & genotypic (G) correlation coefficients among starch properties in pigmented and non-pigmented rice (*Oryza sativa* L.) genotypes**

| Character | | Amylose content | Total starch content | Glycemic index | Slowly digestible starch | Rapidly digestible starch | Resistant starch |
|---|---|---|---|---|---|---|---|
| Amylose content | P | 1.000 | 0.020 | 0.201 | -0.001 | - 0.069 | 0.330* |
| | G | 1.000 | 0.017 | 0.222 | -0.003 | -0.078 | 0.344* |
| Total starch content | P | | 1.000 | -0.003 | -0.003 | 0.130 | -0.152 |
| | G | | 1.000 | -0.004 | -0.006 | 0.128 | -0.153 |
| Glycemic index | P | | | 1.000 | **-0.823*** | **0.888*** | **-0.586*** |
| | G | | | 1.000 | **-0.839*** | **0.904*** | **-0.602*** |
| Slowly digestible starch | P | | | | 1.000 | **-0.902*** | 0.333* |
| | G | | | | 1.000 | **-0.919*** | 0.338* |
| Rapidly digestible starch | P | | | | | 1.000 | **-0.581*** |
| | G | | | | | 1.000 | **-0.588*** |
| Resistant starch | P | | | | | | 1.000 |
| | G | | | | | | 1.000 |

* p values significant at <0.01 P: Phenotypic correlation G: Genotypic correlation
The values in bold are highly correlated

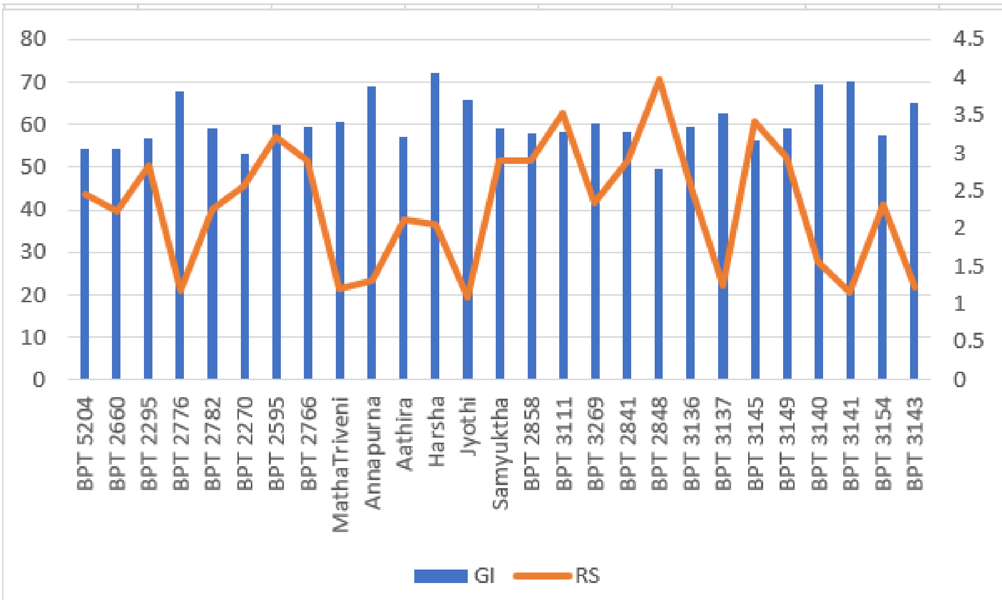


**Fig.1. Correlation between Glycemic Index and Resistant Starch in pigmented and non-pigmented rice genotypes**

0.344*), suggesting that higher AC levels contribute to reduced starch digestibility and increased RS content. This aligns with findings from previous studies by Ramadoss *et al*., (2019) and Kumar *et al*., (2018). Jenkins (2007) also reported that consuming the foods with low GI and elevated RS levels can potentially mitigate the effects of Type II diabetes and cardiovascular diseases, aiding in their dietary management.In the present study also it was established that a strong negative correlation between GI and slowly digestible starch (SDS) (-0.823* & -0.839*) (**Fig. 2**), andpositive relationship with rapidly digestible starch (RDS) (0.888* & 0.904*). SDS showed a significant negative correlation with RDS (-0.902* & -0.919*) and a positive correlation with RS.Furthermore, RDS demonstrated a negative significant relationship with RS at both genotypic (-0.588*) and phenotypic levels (-0.581*). Overall, our findings suggest that genotypes with lower RDS and higher SDS and/ or RS content tend to exhibit lower GI values.

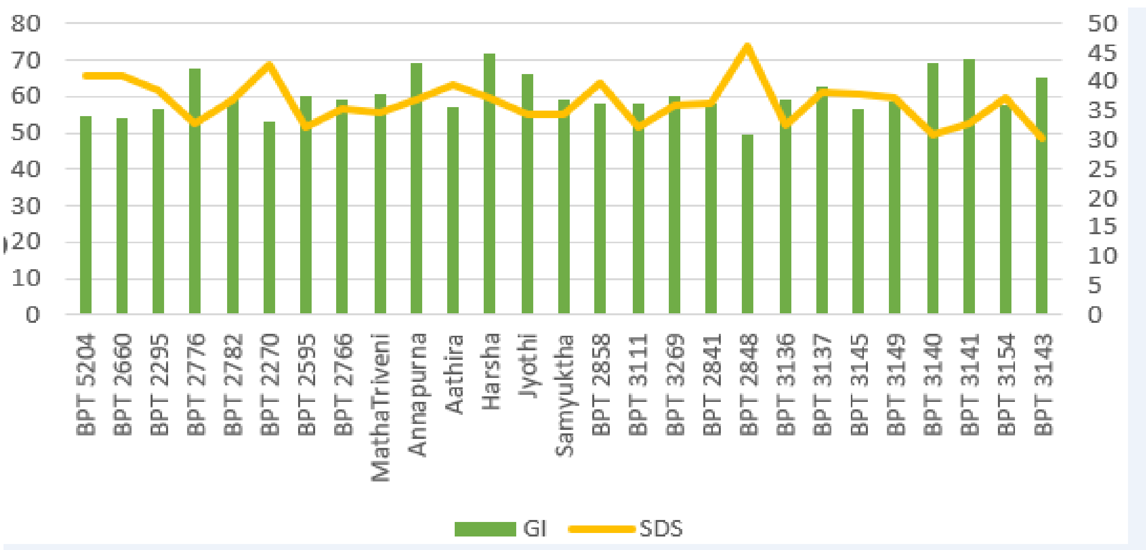


**Fig. 2. Correlation between Glycemic Index and Slowly Digestible Starch in pigmented and non-pigmented rice genotypes**

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Numerous prior studies have highlighted that pigmented rice contain higher levels of anthocyanins, micronutrients, and AOA when compared to their non-pigmented counterparts (Nam *etal.,* 2006; Finocchiaro *et al.,* 2007; Ahuja, 2008; Pathak *et al.,* 2017; Yuehan *et al*., 2018). However, there were minimal variations observed in the starch profiles between coloured and non-pigmented rice genotypes. Denardin *et al.,* (2007) noted that the genotypes with high amylose content tend to have lower glycemic index (GI) values compared with low amylose/ glutinous genotypes. Additionally, Sajilata *et al*., (2006) identified a positive correlation between amylose content (AC) and resistant starch (RS), suggesting that higher AC levels can reduce starch digestibility in food. For individuals with diabetes seeking to leverage the benefits of bioactive compounds, incorporating colored rice with high RS and slowly digestible starch (SDS), along with a low or medium GI, into their diet may effectively help manage and stabilize blood glucose levels without complications.

In this study, BPT 2841, BPT 2858, BPT 2848, BPT 3111, and BPT 3145, BPT 3141 and BPT 3149 were recorded as the most desirable starch properties coupled with excellent physico-chemical and cooking characters and high AOA. Hence, these genotypes may be utilized as donors in future breeding programs also for development of non-glutinous pigmentedgenotypes with excellent cooking quality and high consumer preference. The prevalence of Type II diabetes is rapidly increasing worldwide. Therefore, a crucial objective is to identify or develop pigmented and non-pigmented genotypes that are rich in micronutrients, antioxidants, high in resistant starch (RS) and slowly digestible starch (SDS), coupled with low glycemic index (GI). Investigating the characterization of existing black, red, or other pigmented genotypes for their antioxidant activity, starch profiles, and GI could provide valuable insights into these aspects.

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