Madras Agric.J.,2025; https://doi.org/10.29321/MAJ.10.7000JE5

RESEARCH ARTICLE

Unlocking Genetic Variability in Rice: Enhancing Rice Bran Oil and Quality Traits

Arunkumar M 1 , Geetha S 2 *, Ariharasutharsan G 1 , Sharmela P 1 and Sathish kumar R 1

1 Department of Genetics and Plant Breeding, CPBG, Tamil Nadu Agricultural University, Coimbatore- Tamil Nadu, India, 641 003.
2 Department of Pulses, CPBG, Tamil Nadu Agricultural University, Coimbatore- Tamil Nadu, India, 641 003.

Received: 17 May 2025

Revised: 27 May 2025

Accepted: 05 Jun 2025

ABSTRACT

The unpolished white rice with bran is more nutritious than milled or polished white rice. The edible, Rice-bran oil (RBO) is extracted from rice bran, which contains 12 to 23% lipid, and the quantity of oil extracted is influenced by factors, viz., Variety of seed, extent of milling, extraction technique, and agro climatic conditions. It is rich in antioxidants and improves the shelf life of RBO. This study assessed genetic variability and trait associations in rice genotypes to identify those with superior RBO content and quality traits. Significant differences were observed among genotypes for all studied traits. Bran oil percentage ranged from 12.3% to 20.2%, with the highest levels in varieties ADT54 and Kichadi Samba, and the lowest in *Boothakali Karupan, Moota Kuruva*, and *Kallan Samba*. High phenotypic (PCV) and genotypic (GCV) coefficients of variation were noted for the number of productive tillers, flag leaf length, total spikelets per panicle, thousand-grain weight, and grain yield per plant. Heritability estimates ranged from 73.68% to 99.49%, with high heritability coupled with high genetic advance as a percentage of mean (GAM) for key traits indicating additive gene action. Bran oil percentage showed positive significance and correlation with brown rice recovery, productive tillers, and milling percentage. Path analysis revealed that flag leaf width, grain yield per plant, head rice recovery, and brown rice positively affected bran oil percentage. In conclusion, the genotypes ADT54, *Kichadi Samba*, and CR 1009 demonstrated high potential for RBO content. These findings provide valuable insights for breeding programs focused on enhancing rice bran oil yield and quality, highlighting the potential of genetic selection to meet the increasing demand for RBO and improve rice quality traits.

Key words: *Rice, Bran Oil, Quality traits, Variability, Correlation*

INTRODUCTION

Rice (*Oryza sativa* L.) is a crucial cereal crop that is a primary food source for half of the global population. India, one of the world's largest producers and consumers of rice, has made significant progress in rice cultivation. Rice serves as a staple food for most of the Indian population, especially in the eastern and southern regions. Due to the rapid increase in the global population, it is expected to feed 9 billion people by 2050 (Arunkumar *et al.*, 2022). Rice grain quality has emerged as a primary concern for rice breeders and consumers. The milling yield of the grain plays a crucial role in determining both the yield of head rice and the rate of broken kernels in milled rice.

*Corresponding author mail: arunajithmak10@gmail.com

Rice bran, which comprises the outer brown layer of the rice kernel consisting of the pericarp, aleurone, seed coat, and germ, is a valuable by-product obtained after the rice polishing process (Sohail *et al.*, 2017). Due to its high nutrient content, Unpolished rice containing bran is more nutritious than milled or polished white rice. Nevertheless, rice consumers prefer to consume polished white rice, even though brown rice contains valuable nutrient content. Rice bran containing 12 to 23 percent lipid can be extracted to obtain rice-bran oil (RBO). Typically, the yield of rice bran is around 8-10% of paddy rice (Punia *et al.*, 2021). The amount of RBO extracted depends on various factors such as seed variety, degree of milling, extraction method, and agro-climatic conditions (Ghosh, 2007).

Rice bran oil is a healthy edible oil that has a balanced source of 39% polyunsaturated (linoleic acid), 19% saturated (palmitic acid), and 42% monounsaturated (oleic acid) fatty acid, so RBO is one of the most nutritious edible oils (Mezouari *et al.*, 2006). Bran has a sufficient amount of antioxidant (γ-oryzanol) and nutritionally essential components such as minerals, vitamin E (tocopherols and tocotrienols), phytosterols, and phenolic components (Sohail *et al.*, 2017). It also helps to reduce LDL cholesterol, protects against cardiovascular diseases, and has anticancer effects (Awad-Allah *et al.*, 2022, Punia *et al.*, 2021). RBO has a significantly longer shelf life than other cooking oils because of its antioxidants. Due to its low viscosity, it absorbs less oil during cooking, resulting in fewer calories overall (Chakrabarty, 1989). It is commonly blended with other vegetable oils to enhance the cooking quality of rice bran oil due to its relatively low smoking point.

The prime objective of plant breeding programmes is genetic variability, which results from genetic differences among individuals within a population. Proper management of diversity can result in a permanent improvement in the plant's performance and can serve as a buffer against seasonal instabilities. Genetic variability among traits is essential for breeding and in selecting desirable types (Sadhana *et al.*, 2022). Estimates of heritability help plant breeders in selecting traits for which selection would be effective. Heritability, along with genetic advance, helps to identify the gene action. The association studies between quantitative and quality traits are helpful for the breeders in their selection strategies for crop improvement. This study evaluates the genetic variability and trait associations among rice genotypes to identify those with superior rice bran oil (RBO) content and quality traits.

MATERIALS AND METHODS

The experimental material consisted of 32 genotypes, including landraces and improved cultivars. All the genotypes were obtained from the Department of Rice, Tamil Nadu Agricultural University, Coimbatore. The field experiment was laid out in a Randomized Block Design (RBD) with three replications at the Department of Rice, TNAU, Tamil Nadu, during the rabi season, 2023, following standard agronomical practices. The observations were recorded on each genotype *viz.,* Plant height (cm), flag leaf length(cm), flag leaf width(cm), panicle length(cm), number of grains per panicle, thousand grain weight (g), single plant yield (g), brown rice recovery, milling (%), head rice recovery, Bran (%), bran oil (%).

Rice bran was extracted from all the genotypes with a laboratory miller and kept immediately at 4ºC to control the growth of rice bran free fatty acid (FFA) growth. The rice bran oil content was determined using a Soxhlet apparatus, 5 grams of bran were placed in a packed bed within a thimble, which was then inserted into a distillation flask in a Soxhlet apparatus containing 10 ml of petroleum ether. The extraction process continued until completion. The petroleum ether was evaporated after extraction to separate it from the oil. The weight of the extracted rice bran oil was then measured and recorded, and standardized in the near-infrared spectroscopy (NIR) instrument (M/s ZEUTEC, Germany; Model: SPA 1.0), which was calibrated with the oil content of rice bran ranging from 12 – 23%. R^2 value was 92.8. The analysis of unknown oil content samples of each genotype was recorded by scanning samples in a wave number range of 1400 – 2400 wave length/nm.

Statistical analysis

ANOVA for the randomized block design (RBD) was computed at the 5% significance level. Biometric analyses like PCV, GCV, heritability (h^2) and GAM were calculated. Path coefficient analysis was carried out as per the standard method suggested by Dewey and Lu (1959). The statistical analysis, *viz.,* variability and path analysis, was carried out using the TNAUSTAT statistical package (Manivannan, 2014). The correlation coefficient was computed by Pearson's method using R software version 4.2.3.

Table 1. ANOVA for thirteen traits in rice genotypes

Source of variation	df	Mean Sum of Squares												
		PH	NPT	FLL	FLW	PL	NGP	TGW	SPY	BR	MILL	HRR	BRAN	BRAN OIL%
Replication	1	40.01	16.00	07.63	0.001	5.29	420.25	2.10	38.22	11.44	7.22	2.25	0.02	0.37
Genotypes	31	524.53*	37.73*	84.67*	0.05*	11.20*	17232.55*	44.45*	96.72*	36.06*	25.48*	26.47*	1.33*	9.04*
Error	31	19.79	03.74	06.09	0.008	0.64	168.96	0.63	3.68	0.87	0.45	0.62	0.01	0.02

RESULTS AND DISCUSSION

The significant differences were observed among the genotypes for the examined traits while performing ANOVA (Table 1). The finding suggested the presence of inherent genetic variability among the genotypes, and responds positively to the selection. Genetic variability is an essential prerequisite for a crop improvement program and represents enough variation for all traits. Our results are by Sadhana *et al.* (2022) the traits plant height, number of productive tillers, panicle length, thousand grain weight, grain yield per plant, milling percentage, and head rice recovery showed significant differences.

The bran oil percentage ranged from 12.3% to 20.2%, indicating significant differences in the percentage of oil content concerning selected varieties. The highest mean bran oil percentage of 20.2% and 20.1% was observed in the varieties ADT54 and Kichadi samba, respectively. The results indicate that the two varieties had a potential for improving bran oil content in rice. In the experiment, the varieties *viz*., ASD16 (19.5%), CR 1009 (19.6%), and C053 (19.1%) exhibited relatively higher mean bran oil percentages and were further considered for bran oil characteristics improvement. On the lower end of the spectrum, the varieties *Boothakali karupan*, *Moota kuruva*, and Kallan samba possessed a lower mean bran oil percentage of 12.5% (Figure 1).

The success of genetic improvement depends upon the existing genetic variability and the efficiency in selecting traits. The quantification of variation in the genotypes is indispensable for improving the traits. Therefore, quantifying genotypic variance helps enhance the trait of interest. The assessment

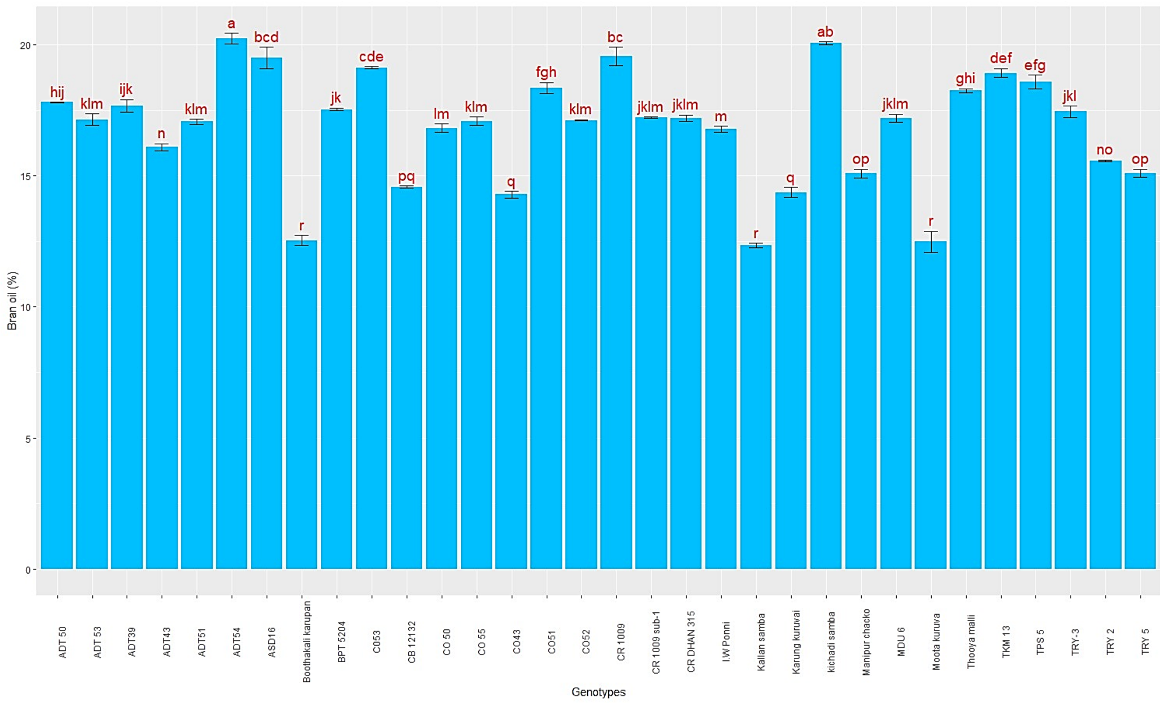

Figure 1. Mean Performance of 32 Rice Genotypes for Bran Oil Percentage

of existing variation can be made by discriminating the genetic variance from the phenotypic variance by avoiding the environmental variance. The variance components estimated were PCV, GCV, heritability (h^2), and genetic advance as a cent of the mean and tabulated in Table 2.

The difference between PCV and GCV was found to be minimum, and it indicated the lesser influence of the environment on the expression of traits. The PCV was considerably higher than the GCV for all the traits. The traits, viz., number of productive traits, flag leaf length, total spikelets per panicle, thousand grain weight, and grain yield per plant, revealed high PCV and GCV. It showed the presence of a significant amount of genetic variability for these traits, and similar results were reported by Sadhana *et al.* (2022) and Zahid *et al.* (2006). These traits are suitable for selection in a crop improvement programme. Whereas, moderate GCV was observed for plant height traits, bran, and bran oil %. This result was in agreement with earlier reports GUPTA *et al.* (2016) and (Babu *et al.*, 2017). The traits panicle length, brown rice, milling % and head rice recovery displayed a low PCV and GCV. The results represent the need for special breeding procedures for improving the traits exhibiting low PCV and GCV. Similar results were obtained by Adjah *et al.* (2020).

The heritability ranged from 73.68 - 99.49 %. High heritability was noticed for all the evaluated traits *viz.,* plant height (92.73 %), number of productive tillers (81.96 %), flag leaf length (86.59 %), flag leaf width (73.68 %), panicle length (89.18%), TSP (98.06%), thousand grain weight (97.22%), grain yield per plant (92.67%), brown rice (95.27%), milling % (96.51%), head rice recovery (95.40%), bran (99.12%) and bran oil % (99.49%). Sadhana *et al.* (2022) obtained similar results and reported high heritability for the characters *viz.,* plant height, number of productive tillers per plant, panicle length, number of grains per panicle, thousand grain weight, grain yield per plant, milling percentage, and head rice recovery. Arya *et al.* (2024) reported the same results for the trait bran oil content, which had high heritability.

The genetic advance as percent of mean (GAM) varied between 10.80 and 91.81%. The high GAM was obtained for the traits *viz.,* plant height (30.26 %), number of productive tillers (48. 24 %), flag leaf length (39.04), TSP (91.81 %), thousand grain weight (45.11 %), grain yield per plant (53.02), bran (28.72 %) and bran oil % (25.89 %). A similar result was observed by Sadhana *et al.* (2022) only for the traits thousand grain weight and grain yield per plant. Other traits, viz., flag leaf width (19.69%), panicle length (18.28%), brown rice (11.46%), milling% % (10.48%), and head

Table 2: Estimates of genetic variability for thirteen characters in rice genotypes

Traits	Minimum	Maximum	PCV%	GCV%	h^2 %	GAM %
PH	83.5	166.0	15.84	15.25	92.73	30.26
NPT	10.5	27.0	28.57	25.86	81.96	48.24
FLL	16.0	46.0	21.89	20.37	86.59	39.04
FLW	1.2	2.0	12.97	11.13	73.68	19.69
PL	21.4	29.6	9.95	9.39	89.18	18.28
NGP	82.0	441.5	45.45	45.00	98.06	91.81
TGW	11.6	28.9	22.52	22.21	97.22	45.11
SPY	12.8	41.8	27.77	26.64	92.67	53.02
BR	61.6	79.2	5.84	5.70	95.27	11.46
MILL	59.2	72.5	5.43	5.33	96.51	10.80
HRR	50.4	68.0	6.09	5.95	95.40	11.97
Bran	4.3	8.1	14.08	14.02	99.12	28.76
Bran Oil	12.3	20.2	12.63	12.60	99.49	25.89

(PH-plant height, NPT-number of productive tillers, FLL- flag leaf length, FLW- flag leaf width, PL-panicle length, NGP-number of grains per panicle, TGW-thousand grain weight, SPY-single plant yield, BR- brown rice recovery, MILL- milling %, HRR-head rice recovery) rice recovery (11.97%), recorded moderate GAM in the genotypes. Similarly, Adjah et al. (2020) reported the same results for brown rice and milling percentage traits. The high heritability along with high GAM was accompanied by the traits plant height, number of productive tillers, flag leaf length, TSP, thousand grain weight, grain yield per plant, bran, and bran oil %. The obtained outcomes indicated that these characters were controlled by additive gene action, the environmental effect was minimal, and the selection could be effective for the genetic enhancement of the traits.

Assessing the relationship between yield and its component traits aids the plant breeders to improve the genetic potential of the genotypes in a desirable direction. The correlation coefficient among different traits is presented in Figure 2. Bran oil% % showed a positive and significant correlation with brow rice recovery (r = 0.610), productive tillers (r = 0.433), milling percentage (r = 0.497), and NGP (r = 0.301). Similar results were reported by Adjah *et al.* (2020). These outcomes figured out that the traits, viz., productive tillers, number of grains per panicle, and milling% were the important selection indices to improve the bran oil% trait. The bran oil percentage trait was non-significant and positively related to flag leaf length (r = 0.045), flag leaf width (r = 0.212), grain yield per plant (r = 0.196), and head rice recovery (r = 0.210). The characters *viz.,* plant height (r = -0.065), panicle length (r = -0.003), thousand grain weight (r = -0.233), and bran (r = -0.135) were non-significant and negatively associated with bran oil% %. Similar results were provided by the authors Manivelan *et al.* (2022) for the traits panicle length and head rice recovery.

Regarding inter-correlation, the number of productive tillers displayed a significant and positive association with the number of grains per panicle, brown rice recovery, milling %, and a significant negative correlation with thousand grain weight. Similarly Sadhana *et al.* (2022) reported for the traits, brown rice, and milling percentage. The trait brown rice recovery expressed significant and positive inter-correlation with milling%, head rice recovery, and significant negative correlation with Bran. Milling% exposed positive and significantly associated with head rice recovery and negatively associated with bran. Number of grains per panicle showed a positive and significant correlation with milling %, brown rice, and a negative and significant correlation with thousand-grain weight. Lakshmi and Chamundeswari (2021) reported positive and significant correlation for brown rice traits, head rice recovery and milling percentage.

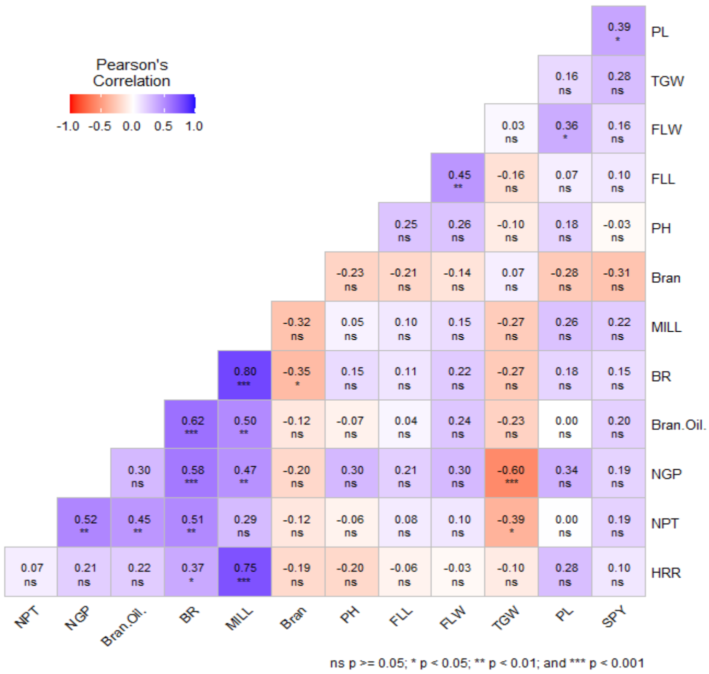

Figure 2. The Pearson's Correlation co efficient among quantitative and quality traits *, ** Significant at 5% and 1% level, respectively

Table 3: Path co-efficient analysis of direct (diagonal) and indirect effects of thirteen traits on bran oil % in rice genotypes

Characters	PH	NPT	FLL	FLW	PL	NGP	TGW	SPY	BR	MILL	HRR	Bran	Bran Oil%
PH	0.037	-0.008	-0.046	0.108	-0.028	-0.188	0.059	-0.024	0.154	-0.024	-0.061	-0.046	-0.065^{NS}
NPT	-0.003	0.079	-0.014	0.026	0.0007	-0.329	0.239	0.091	0.531	-0.140	0.026	-0.028	0.433**
FLL	0.009	0.006	-0.184	0.204	-0.011	-0.128	0.097	0.046	0.110	-0.041	-0.017	-0.043	0.045^{NS}
FLW	0.009	0.005	-0.091	0.413	-0.052	-0.170	-0.031	0.065	0.216	-0.072	-0.006	-0.026	0.212^{NS}
PL	0.007	-0.0003	-0.014	0.149	-0.145	-0.206	-0.091	0.198	0.185	-0.121	0.090	-0.0581	-0.003^{NS}
NGP	0.011	0.043	-0.039	0.116	-0.049	-0.604	0.349	0.090	0.578	-0.214	0.065	-0.043	0.301*
TGW	-0.003	-0.033	0.031	0.022	-0.023	0.368	-0.573	0.135	-0.270	0.120	-0.030	0.017	-0.233^{NS}
SPY	-0.001	0.015	-0.018	0.057	-0.061	-0.116	-0.165	0.469	0.154	-0.099	0.031	-0.063	0.196^{NS}
BR	0.005	0.043	-0.020	0.091	-0.027	-0.356	0.158	0.073	0.979	-0.354	0.111	-0.075	0.610**
MILL	0.002	0.025	-0.017	0.067	-0.039	-0.292	0.156	0.105	0.784	-0.443	0.228	-0.068	0.497**
HRR	-0.007	0.007	0.010	-0.009	-0.043	-0.131	0.059	0.049	0.362	-0.335	0.300	-0.042	0.210^{NS}
Bran	-0.008	-0.011	0.039	-0.054	0.041	0.130	-0.048	-0.146	-0.366	0.148	-0.062	0.203	-0.135^{NS}

(PH-plant height, NPT-number of productive tillers, FLL- flag leaf length, FLW- flag leaf width, PL-panicle length, NGP-number of grains per panicle, TGW-thousand grain weight, SPY-single plant yield, BR- brown rice recovery, MILL- milling %, HRR-head rice recovery)

Residuals 0.3871

The minimal residual effect implies that the chosen traits were highly suitable for conducting path analysis to determine their impact on bran oil %. Path analysis is partitioning correlation coefficient into direct and indirect effects (Table 3). This analysis was made to study the cause and effect of the dependent and independent traits. The traits, flag leaf width (0.413), grain yield per plant (0.469), head rice recovery (0.300), and BR (0.979) exhibited a high positive direct effect on bran oil%. Sadhana *et al.* (2022) also reported the same results for grain yield traits and head rice recovery. Bran showed a moderately positive direct effect on bran oil %. The traits *viz.*, head rice recovery (0.300) and bran (0.203) exhibited a moderate positive effect on bran oil %. The characters *viz.,* flag leaf length (-0.184), panicle length (-0.145), NGP (-0.604), thousand grain weight (-0.573), and milling% (-0.443) revealed an adverse direct effect on the bran oil% % trait. The residual effect was observed as 0.387. These fallouts indicated that the studied traits reliable in contributing to the trait bran oil %. However, 38.71% of the variability remains unexplored in this study, which may contribute to other traits for the enhancement of the trait bran oil%.

CONCLUSION

In this study, Bran and bran oil yield percentage showed high heritability coupled with genetic advance as a percentage of the mean. The expression indicates additive action of genes; further selection and exploitation of traits are beneficial and improve bran oil properties in rice. The *per se* performance for the trait rice bran oil was observed to be high for genotypes ADT 54, Kichadi samba, and CR 1009. These genotypes can be utilized in breeding programmes to improve the rice bran oil percentage. The obtained results infer that the selection of high bran oil-yielding varieties helps in reducing the demand for rice bran oil. These results provide valuable insights for selecting varieties with higher oil content for specific applications in the bran oil industry.

Funding and Acknowledgment

No external funding was received to carry out this research.

Ethics statement

There were no human participants and no animals included in this research.

Originality and plagiarism

The authors assure that we wrote the contents and were not plagiarized.

Consent for publication

All the authors agreed to publish the content.

Competing interests

There was no conflict of interest in the publication of this content

Authors contribution

Idea conceptualization – MA, SG, and GA; Experiments – MA and GA; Guidance - SG; Writing original draft – MA and RS; Writing - reviewing & editing – PS and RS.

REFERENCES

Adjah, Kossi Lorimpo, Ayodeji Abe, Victor O Adetimirin, and Maxwell Darko Asante. 2020. "Genetic variability, heritability and correlations for milling and grain appearance qualities in some accessions of rice (*Oryza sativa* L.)." *Physiology and Molecular Biology of Plants* **26**:1309-1317. https://doi.org/10.1007/s12298-020-00826-x

Arunkumar, M, S Geetha, K Amudha, R Suresh, V Ravichandran, and K Geetha. 2022. "Genetic diversity and QTL-marker association analysis of rice germplasm for grain number per panicle and its contributing traits." *Electronic Journal of Plant Breeding* **13 (2)**:558-566. https://doi.org/10.37992/2022.1302.068

Arya, B., B. Lovely, G. Seeja, V. Mini, and S. Jyothilekshmi. "Unravelling the biochemical traits of traditional rice landraces of Kerala.2024." *Electronic Journal of Plant Breeding* 15, no. 2 : 435-442. https://doi.org/10.37992/2024.1502.060

Awad-Allah, Mamdouh MA, Azza H Mohamed, Mohamed A El-Bana, Samira AF El-Okkiah, Mohamed FM Abdelkader, Mohamed H Mahmoud, Mohamed Z El-Diasty, Manal M Said, Sahar AM Shamseldin, and Mohamed A Abdein. 2022. "Assessment of genetic variability and bran oil characters of new developed restorer lines of rice (*Oryza sativa* L.)." *Genes* **13 (3)**:509. https://doi.org/10.3390/genes13030509

Babu, P Mahesh, Y Chandramohan, V Ravindrababu, and CH Arunakumari. 2017. "Assessment of genetic variability for yield and bran oil content in segregating generations of rice." *Int. J. Curr. Microbiol. App. Sci* **6 (11)**:117-124. https://doi.org/10.20546/ijcmas.2017.611.015

Chakrabarty, MM. 1989. "Rice bran: a new source for edible and industrial oil."

Proceedings of world conference on edible fats and oils processing. AOCS Press, Champaign.

Dewey, Douglas R, and KH Lu. 1959. "A correlation and path-coefficient analysis of components of crested wheatgrass seed production 1." *Agronomy journal* **51** **(9)**:515-518. https://doi.org/10.2134/agronj1959.00021962005100090002x

Ghosh, Mahua. 2007. "Review on recent trends in rice bran oil processing." *Journal of the American oil chemists' society* **84**:315-324. https://doi.org/10.1007/s11746-007-1047-3

Gupta, Ruplata, Sangeeta Tetwar, Ishu Kumar Khute, and Sunil Kumar. 2016. "Quantitative Analysis of Rice Germplasm of Chhattisgarh." *Advances* **5** **(3)**: 1034-1038.

Lakshmi, K, and N Chamundeswari. 2021. "Evaluation of grain quality traits in popular rice varieties of Andhra Pradesh." *Journal of Pharmacognosy and Phytochemistry* **10** **(1)**:217-224. https://doi.org/10.22271/phyto.2021.v10.i1Sd.13443

Manivannan, N. 2014. TNAUSTAT-Statistical package.

Manivelan, K, S Juliet Hepziba, R Suresh, M Theradimani, R Renuka, and RP Gnanamalar. 2022. "Inherent variability, correlation and path analysis in lowland rice (*Oryza sativa* L.)." Biological Forum–An International Journal. **14(2)**: 771-778

Mezouari, Samia, Karl Eichner, S Parkash Kochhar, Ludger Brühl, and Karin Schwarz. 2006. "Effect of the full refining process on rice bran oil composition and its heat stability." *European Journal of Lipid Science and Technology* **108** **(3)**:193-199. https://doi.org/10.1002/ejlt.200500301

Punia, Sneh, Manoj Kumar, Anil Kumar Siroha, and Sukhvinder Singh Purewal. 2021. "Rice bran oil: Emerging trends in extraction, health benefit, and its industrial application." *Rice Science* **28** **(3)**:217-232. https://doi.org/10.1016/j.rsci.2021.04.002

Sadhana, P, Ch Damodar Raju, LV Rao, and Aparna Kuna. 2022. "Studies on variability, correlation and path coefficient analysis for yield and quality traits in rice (*Oryza sativa* L.) genotypes." *Electronic Journal of Plant Breeding* **13** **(2)**:670-678. https://doi.org/10.37992/2022.1302.084

Sohail, Muhammad, Allah Rakha, Masood Sadiq Butt, Muhammad Jawad Iqbal, and Summer Rashid. 2017. "Rice bran nutraceutics: A comprehensive review." *Critical Reviews in Food Science and Nutrition* **57** **(17)**:3771-3780. https://doi.org/10.1080/10408398.2016.1164120

Zahid, M Afzal, M Akhter, M Sabar, Zaheen Manzoor, and Tahir Awan. 2006. "Correlation and path analysis studies of yield and economic traits in Basmati rice (Oryza sativa L.)." *Asian J. Plant Sci* **5** **(4)**:643-645. https://doi.org/10.3923/ajps.2006.643.645