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Nutra-fragnance a sustainability boost of *Odisha* landraces

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ABSTRACT

Odisha, the queen land of aromatic short grain landraces has been studied on 127 prominent landraces focusing on nutrition and aromatic compounds based on consumer demand for value-added products. Rice protein is a distinct bio-macronutrient that influences nutritional quality averaging 9.99% across various landraces with Kalajeera exhibiting the highest content which support the protein levels above 10% are beneficial for combating malnutrition. Variations in protein content may result due to environmental factors, biotic and abiotic stresses and growing conditions. The other nutrient component, Fat which is mostly unsaturated is predominantly found in the aleurone layer and its content can affect rice aroma and taste. Total carbohydrate content varies from 64.28% in Kalajeera to 78% in Basmati-4 with starch composition impacting digestibility and texture. Crude fiber which aids in controlling cholesterol and blood sugar levels ranges from 0.46% to 0.99%. Mineral content shows Zinc levels between 18.37 mg/kg to 23.39 mg/kg and Iron from 6.58 mg/kg to 20 mg/kg with positive correlations observed between protein, crude fiber, starch, and total carbohydrates. PCA analysis identifies notable varieties suitable for improvement and conservation. Additionally, aroma compounds, besides particularly 2-acetyl-1-pyrroline, and acetone newly five identified aromatic compounds Ethane, 1-isothiocyanato-2-methoxy (fruity smell), Dimethyl ether (sweet smell), Formic acid, 1-methylethyl ester (ethereal odour), Alanine (umami smell), and Boric acid trimethyl ester (sweet odour) contribute to the fragrance of these rice varieties. Variations in aromatic compounds are influenced by chemical composition, with high protein correlating to lower aroma intensity. Gas chromatography-mass spectrometry (GC-MS) identified key aroma compounds, particularly 2-acetyl-1-pyrroline (2AP), ranging from 0.14 ppm (Dhusara) to 0.99 ppm (Thakurbhog), underscoring its importance in rice aroma. The finding reveals new scented compounds within indigenous landraces of *Odisha*, highlighting the intricate relationship between nutrient and aromatic profiles in rice.

Keywords: Landrace, Proximate, Aroma, Spectroscopy, Nutrient

Introduction

Asia's role in the cultivation and production of aromatic rice varieties is significant due to its favourable climatic conditions, traditional agricultural practices and rich biodiversity (Smith, 2020) [1]. Regions like India, Thailand, and Vietnam, with their tropical and subtropical climates, provide an ideal environment for aromatic rice growth (Johnson, 2019) [2]. These climates offer the necessary warmth and humidity for varieties such as Basmati and Jasmine, which are in high global demand and are crucial export commodities that significantly contribute to the economies of rice-producing nations in Asia (Lee et al., 2021) [3]. India is a country of Asia, is recognized as a significant producer of diverse rice varieties, particularly aromatic rice land races, predominantly featuring small to medium grains. It is acknowledged as the origin center for cultivated rice, boasting extensive genetic diversity (De Candolle 1886; Vavilov 1992) [4, 5]. These indigenous aromatic rice accessions are cultivated across nearly all Indian states, including *Odisha*. They are distinguished by their unique aroma, superior cooking and eating qualities and enhanced nutritional content compared to basmati rice alongside their adaptability to local environmental conditions. These varieties have naturally evolved over many years, resulting in high genetic diversity and distinct alleles for various agronomic traits (McCouch et al., 1997).

Odisha, a state in eastern India, is known for its rich biodiversity, especially in rice landraces. These landraces are traditional varieties that have been cultivated and passed down through generations, often adapted to local conditions and possessing unique traits. The state has its own set of aromatic short grain rice, which is being cultivated in almost all districts in different agro-climatic zones. The aromatic rice is considered sacred among the people. These rice accessions hold enormous potential to be utilized as value added products, thereby providing higher economic return to small and marginal farmers and hold significant cultural

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and aesthetic value due to their distinctive aroma and superior grain quality. It is found from review the aromatic landraces are comparatively lesser yield value due to various agro-morphological characteristics like tall plant leads to high lodging, low response to nutrients, despite of this, the farmer of the land unhabituated to grow landraces in their own practice (Rao *et al.*, 2006; Dixit *et al.*, 2013) [7, 6].

Aroma in rice is primarily attributed to the presence of 2-acetyl-1-pyrroline (2AP), a volatile compound that gives rice its characteristic fragrance. The aroma is influenced by genetic factors, with certain genes controlling the synthesis of 2AP. In *Odisha*, aromatic rice landraces are often evaluated using sensory methods and molecular markers to identify genotypes with desirable aroma traits (Panda *et al.*, 2020; Hossain *et al.*, 2020) [9, 8]. Proximate composition which includes moisture, protein, fat, fiber, and ash content and these components are essential for settling the nutritional quality and processing characteristics of rice. Landraces of *Odisha* have been studied for its proximate composition to understand their nutritional importance and potential for breeding programs. To understand the aroma and proximate composition of rice landraces is crucial for several reasons, like breeding programme on identifying and incorporating desirable traits

into new rice varieties can enhance their market value and consumer acceptance (Chaudhary *et al.*, 2001; Prodhan *et al.*, 2020) [10, 11]. On documenting the unique traits of landraces that helps in their conservation, sustainable use and in increasing economic value as aromatic rice often commands a premium price in the market making it economically beneficial for farmers. To satisfy the demand of need, promoting the market, provide value added to farmers, this study of aroma with proximate composition in rice landraces of *Odisha* is itself a challenge to fill the gap and find the varieties of landraces on the mid-economic land like *Odisha*. This provides valuable insights into their genetic diversity, nutritional quality, and potential for improving rice varieties (Singh *et al.*, 2005) [12].

Methodology

Estimation of carbohydrate by Anthrone method

The powdered rice sample was taken in a boiling tube. It was hydrolyzed for 3 h with 5 ml of 2.5 N HCl. Cooled and neutralized by adding solid sodium carbonate followed by centrifugation. Then it was spectroscopically analysed against standard and the value was calculated.

$$\text{Carbohydrate in 100 mg sample} = (\text{mg of glucose/Volume of test sample}) \times 100$$

Estimation of starch by Anthrone reagent

The milled rice was taken for estimation of starch by following Sadasivan and Manickam (1991). The rice sample was homogenized in hot ethanol (80%) followed by centrifugation. Repeated washing was done with ethanol by testing with anthrone reagent followed addition of 5 ml of water and 6.5 ml of 52% perchloric acid. Then it was spectroscopically analysed against standard and the value was calculated.

Estimation of protein by Lowry's method

Powdered rice sample was taken by adding buffer against Bovine serum as standard. The test followed by 5 ml of alkaline copper solution, 0.5 ml of Folin-ciocalteu. The test was spectroscopically analysed.

Estimation of free fatty acids (Sadasivam and Manickam, 1992)

Powdered rice sample and absolute ethanol was taken for analysis followed by a few drops of phenolphthalein. The titration was done against 0.1N potassium hydroxide. Then it was calculated by,

Assessment of Crude fiber content (Sadasivam and Manickam, 1992)

Dried powdered sample was taken along with 200 ml of sulphuric acid followed by adding 200 ml of sodium hydroxide solution. Then it was washed with 25 ml of boiling 1.25% H₂SO₄. Again, it was washed with three 50 ml parts of water and 25 ml of alcohol. The residues were removed and it was transferred to a washing dish (pre weighted dish W₁). The residue was dried for 2 h at 130 ± 2 °C. The dish was cooled in a desiccator and the weight was taken (W₂). It was then ignited for 30 minutes at 600 ± 15 °C. It was then cooled in a desiccator and reweight was taken (W₃). Fiber content was calculated using the following formula.

$$\text{Fatty acid value (mg KOH/g)} = \frac{\text{Titrate value} \times \text{Normality of KOH} \times 56.1}{\text{Weight of the sample (g)}}$$

Assessment of mineral content (Iron and Zinc) -by wet digestion process using atomic absorption spectrophotometer.

Powdered rice sample was digested with 10 ml of diacids mixture (nitric acid and perchloric acid) at a ratio of 2:1 (v/v). The absorbance of the standard solution and the sample solution was taken by atomic absorption spectrophotometer at 560 nm and 510 nm respectively. Then the concentration value was plotted and noted down from graph on known to unknown value.

Biochemical identification, of scented compounds

Separation and analysis of volatile compounds were done using HS-SPME coupled with GC-MS (Varian 430-GC and 210-MS, Japan) with a factor four capillary column VF5-MS (30 m × 0.25 mm × 0.25 μm) of 5% diphenyl, 95% dimethylpolysiloxane. Research-grade helium (99.999%) was used as the carrier gas under a constant flow of 28.6 cm/s (1 mL/min). The SPME fiber was desorbed for 5 min in the

GC injector with a temperature of 260 °C. The optimum performance of the SPME fiber was monitored after every ten extractions with the standard fiber maintained separately. The fiber showing comparable performance was continued in further analysis. The GC oven program was optimized for the separation of 2AP from the seed. Initially, the oven temperature was kept at 45 °C for 1 min and ramped to 55 °C at a rate of 5 °C/min, then increased to 120 °C at a rate of 9 °C/min, further ramped to 240 °C at a rate of 15 °C/min with a final hold of 1 min. The total GC cycle consisted of 19.22 min of runs and 1 min of destabilization time. A blank run of GC-MS was also performed after every sixth sample to remove any traces from earlier runs in the GC column. The injector temperature was maintained at 260 °C and the transfer line was held at 230 °C. The detection was performed by a Saturn III mass spectrometer in the EI mode (ionization energy, 70 eV; source temperature, 180 °C). The MS was operated in the scan mode from m/z 35-275. Identification and quantification of 2AP and other volatiles were conducted by comparing the m/z pattern of each peak with the library data.

$$\text{Crude fiber(\%)} = \frac{\text{Loss of weight on ignition (W2 - W1) - (W3 - W1)}}{\text{Weight of the sample (g)}} \times 100$$

Statistical analysis

Statistical analysis and Principal component analysis (PCA) was conducted on the different traits using PAST-4.03 software to identify sources of variability.

Results and Discussion

Nutritional quality

Protein of rice is a major identifiable bio macronutrient that impact the nutritional quality Sompong *et al.* (2011) [13] due to its special amino acid composition though the amount is less in rice. The results find mean protein value 9.99% maximum in Kalajeera and 9.670% percentile of studied landraces are having good protein content which is close agreement to Resurrection *et al.*, (1979) [14]. Protein content greater than 10% is mostly acceptable by food products and can be used to cure malnutrition Resurrection *et al.*, (1979) [14]. The lower and similar result has been found by Masniawati *et al.* (2018) [15], Juliano *et al.*, (1985) [16], Anjum *et al.*, (2007) [17], Chaudhary *et al.*, (2001) [10] and Verma *et al.*, (2017) [18]. The variation of protein content in rice may be due to environment, biotic and abiotic stresses, and application of fertilizer, growing areas, temperature and growth condition for synthesis and accumulation of protein in rice Buresova *et al.*, (2010) [19]. Fat is another bio macronutrient representing the linoleic acid and other fatty acid without cholesterol Eggum *et al.*, 1982 [20]. Low fat content is also a mark of aromatic short grain Singh *et al.*, 1998 [21]. The taste of rice may differ due to high fat content and less starch. The results are in agreement with earlier findings (Verma & Srivastav, 2017 [18]; Chen *et al.*, 2004 [22]; Cameron and Wang, 2005 [23]; Rohman *et al.*, 2014 [24]; Saikia, 2012; Sompong *et al.*, 2012). The fat in rice is mostly present at the aleurone layer of the kernel so, milling is the major cause of variation in getting it from storing nutrient of rice Wang *et al.*, 2004 [25]. The variation of fat which is mostly unsaturated due to oxidation by atmospheric oxygen. Total carbohydrate comprises starch and cellulose. Total carbohydrate percentage ranged 64.281% of Kalajeera to 78% of Basumati-4, the result is in agreement with earlier finding of Verma *et al.*, (2017) [18]. In total carbohydrate the starch comprising amylose and amylopectin. Rice starch is quick digest nutrient component than other starchy food Oko *et al.*, 2012 [26]. The result shows Starch content ranges 66.9% of Gitanjali to 91.89% of Chinikamini. Similar result studied by Subudhi *et al.* (2013) [27] and Shayo *et al.*

(2006) [28], whereas lower content has been reported by, Oko *et al.*, (2010) [29], Ebuchi *et al.* (2006) [30], Yadav *et al.* (2007) [31], Thomas *et al.*, (2013) [32], Verma & Srivastav, (2017) and Saikia *et al.*, (2012) [33]. The lower starch content is the cause of no stickiness of rice whereas higher value is the cause of stickiness of rice after cooking Mbatchou *et al.* (2013) [34]. Crude fibre the important macronutrient biochemically reduces the blood cholesterol and decreases blood sugar which help in control of diabetics Yeager, (1998) [35] also release constipation by controlling bowel disorders FAO/WHO, (1998) [36]. The diet fibre directly enhances the bulk of faeces that evacuate out-turn in gut (Mbatchou *et al.*, 2013) [34]. It is studied that well refined rice has crude fiber percentage ranged from 0.5% to 1.0% (Okoko *et al.*, 2010) [29]. The present result of crude fiber percentage ranges from 0.46% (Bishnubhog) to 0.99% (Acharamati and Thakurbhog) that is little lower and close to an agreement to the standard value (Verma *et al.*, 2017; Ibukun, 2008; Mbatchou and Dawad, 2013 and Shayo *et al.*, 2006) [18, 37, 34]. The present finding of, fiber percentage are lower than the findings of many researchers (Okoko *et al.*, 2012; Rohman, 2014; Anjum *et al.*, 2007; Thomas, 2013; Sompong *et al.*, 2011) [26, 24, 17, 32, 13] whereas it is higher than the finding of Saikia, (2012) and Diako *et al.* (2011) [38]. The digestibility of rice impacted by crude fibre. The digestibility will be lower in higher content of crude fiber in diet (WHO, 1985) [39]. The minerals are the bio micronutrients of rice effectively play its role in bio metabolic pathway. The Zinc ranges from 18.370 mg/kg to 23.390 mg/kg and Iron ranges from 6.58 mg/kg to 20 mg/kg. The result is in agreement with Juliano, (1980) [40]. Level of Zinc decreases by milling (Itani *et al.*, 2004) [41] (Fig 1).

The correlation (Table 1; Fig 2) shows protein is significantly and positively correlate with crude fiber ($r = 0.300^{**}$), with starch ($r = 0.203^{*}$) and with total carbohydrate ($r = 0.261^{**}$). Crude fiber with Iron ($r = 0.196^{*}$). Similarly Starch with Zinc ($r = 0.230^{**}$). This signifies the various nutrient traits concentration are dependent among themselves. The PCA study (Table. 2) results Thakurbhog, Kalajeera-7, Pimpudibasa, Krunabhog, Dubraj-2, Basumati, Jaygopal might be exploited for crop improvement, plant breeding and genetic conservation program. The present finding on nutrient traits correlation among Protein with crude fiber ($r = 0.300^{*}$) and with carbohydrate ($r = 0.261^{**}$) is in equivalent support of Meena *et al.* (2020) [42] who recorded protein was significantly correlate with amylose content. (A-Protein%, B- Crude fat%, C- Crude Fibre%, D-Starch%, E- Total Carbohydrate%, F- Iron(mg/kg), G-Zinc(mg/kg))

Table 1. Pearson correlation among Nutrient characters of studied aromatic landraces.

	A	B	C	D	E	F	G
A							
B	-0.034						
C	0.300**	0.082					
D	0.203*	-0.520	0.102				
E	0.261**	0.139	0.138	0.133			
F	0.093	0.225	0.196*	-0.034	0.109		
G	0.005	-0.068	0.055	0.230**	0.071	-0.023	

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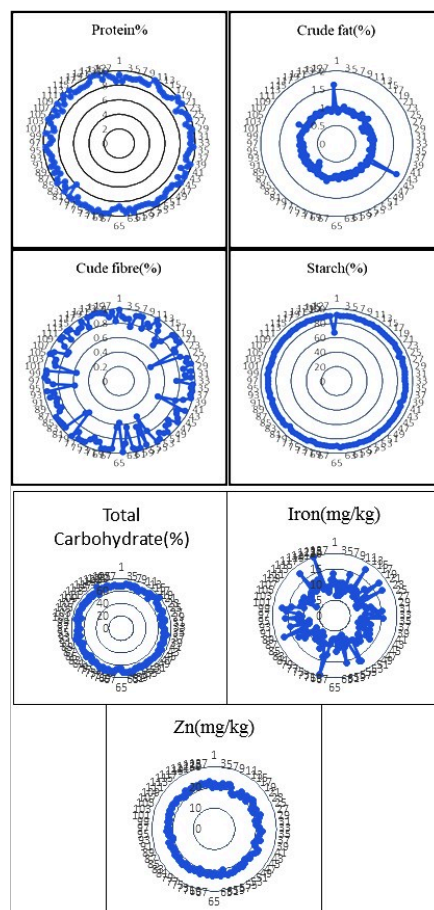


Figure 1. Radar graph showing nutrient traits of studied aromatic landraces

A-Protein%, B- Crude fat%, C- Crude Fibre%, D-Starch%, E- Total Carbohydrate%, F- Iron(mg/kg), G-Zinc(mg/kg).

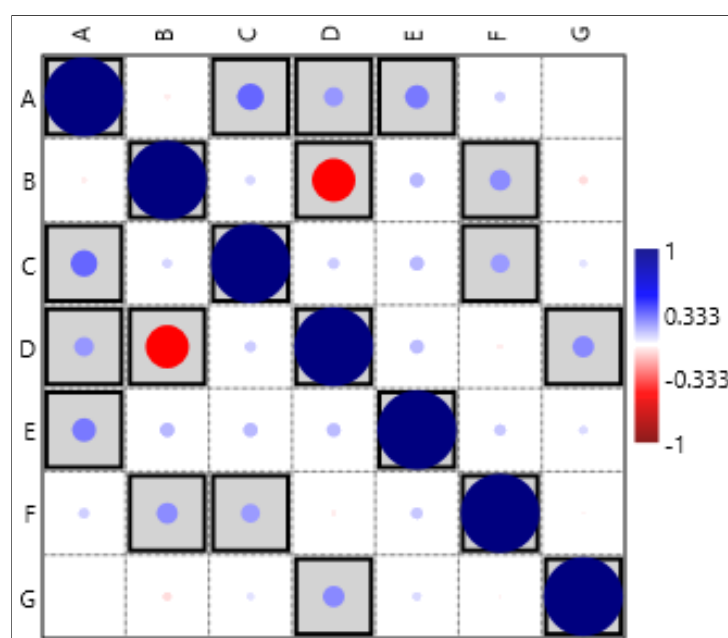


Figure 2. Graph showing Pearson correlation among different nutrient traits of aromatic landraces.

(A-Protein%, B- Crude fat%, C- Crude Fibre%, D-Starch%, E- Total Carbohydrate%, F- Iron(mg/kg), G-Zinc(mg/kg))

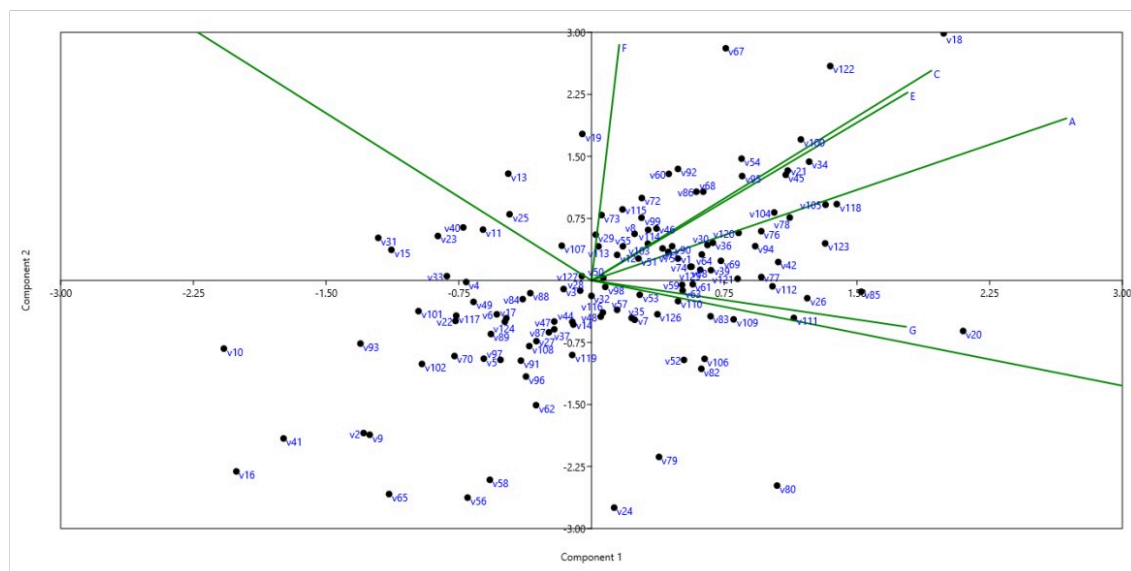


Figure 3. Scattered plot of nutrient characters of studied aromatic landraces based on PCA.

Scatter diagram of PCA on nutrient characters of different aromatic landraces were observed. The scatter diagram grouped the landraces into four quarters. In the first quarter (X, X) 42 genotypes such as sunsuniasunaphool, Kalajeera-5, Pimpudibasa, Tulashi, Kalamalliphula etc. were present based on nutrient characters such as crude fibre, Iron, Protein, and total carbohydrates. In the second quarter (-X, Y) 9 landraces (Desibasumati, Durgabhog, Basubhog, Ramachandrabhog, Bindli etc.) were present based on crude fat%. In the fourth quarter (X, -Y), 23 landraces (Krishnabhog, Basumati, Kanika, Heerakhandi, kalakati, Raktasiali etc..) were present based on nutrient character like Zinc and starch. In third quarter there was no differentiation of landraces based on nutrient characters. (Fig. 3).

Detection of scented compounds by GCMS analysis

In a detail analysis of 128 rice landraces using GCMS headspace techniques, a diverse array of scented compounds was identified (Fig. 4). The predominant chemical groups associated with the aroma encompassed alkanes, heterocycles, ethers, esters, ketones, and aliphatic amino acids. Notably, 2-Acetyl-1-pyrroline (2AP), which imparts a characteristic popcorn aroma, was consistently present across all landraces, reinforcing its significance in rice aroma research. Along with this Ethane, 1-isothiocyanato-2-methoxy is notable for its fruity scent and is prominent in the Basumati landrace which demonstrated multiple peaks associated with this compound. The results justify on existing studies that have established the crucial role of 2AP in rice fragrance and it was established that concentration of 2AP is a strong determinant of the aromatic quality in rice varieties especially in traditional landraces such as Jasmine and Basmati. However, the detection of other new compounds like Dimethyl ether and Formic acid, 1-methylethyl ester adds depth to the aromatic profile of the rice that suggests the potential unexplored avenues for enhancing aroma through breeding and processing. Focusing and finding of other studies like by Juliano *et al.* (1985) [16] and Koh *et al.* (2007) on the quantification and sensory evaluation of aromatic compounds, this study provides a more nuanced chemical profiling of the landraces. The comprehensive mass fragmentation patterns and retention times documented contribute valuable data for further genetic studies and breeding programs aimed at improving aromatic properties. The result finding of this particular research not only corroborates previous findings on key aroma compounds but also expands the known aromatic spectrum of rice, determining the complexity and diversity present in different landraces. Further studies could build on these findings to explore the relationship between specific compounds and sensory attributes, potentially guiding the development of rice varieties with enhanced aroma profiles for culinary applications.

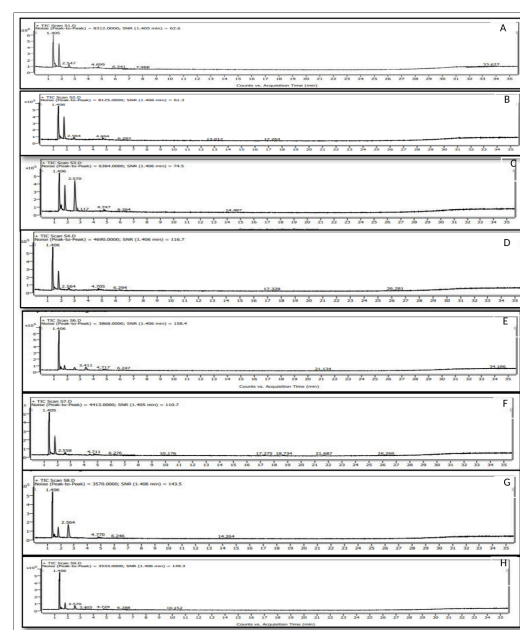


Figure 4. Graph showing different aromatic compounds of studied aromatic landraces.

A-Sunsuniasunaphool, B-Thakurbhog, C-Basumati, D-Nadiapula, E-Jaiphool, F-Dubraj-ii, G-Chinikamini, H-Dhusara

Analysis of aromatic compounds

Rice that discharges fragrance on hulling and cooking (Jefferson, 1985) [43] is mostly due to aromatic compounds biosynthetically present in it. The aroma in aromatic rice is produced, accumulated and varied due to genetic (Panda *et al.*, 2020) [9], preharvesting conditions like environmental, abiotic stress, temperature, soil and cultural practices (Hossain *et al.*, 2020) [8]. 2AP compound which is popcorn like smell, (Tanchotikul *et al.*, 1991) [44] is mostly present in all studied aromatic short grain landraces. Similar result was found by (Hinge *et al.*, 2016) [45]. This compound was detected as contributor of aromatic odour (Buttery *et al.*, 1982) [46]. The quantification results minimum concentration 0.14 ppm in Dhusara and maximum 0.99 ppm in Thakurbhog. 2-acetyl-1-pyrroline concentration in Della (76.2 ppb), Basmati 370 (87.4 ppb) and in Jasmine (156.1 ppb) was also found. Buttery *et al.*, 1983 [47] found the concentration of similar 2-acetyl-1-pyrroline in 10 aromatic rice which range from 0.09 ppm-0.006 ppm in milled rice and 0.2 ppm to 0.1 ppm. in brown rice. The surface layer is the major storage region of aromatic compound in grain of aromatic rice for which the raw milled or brown rice had 2-acetyl-1-pyrroline

concentration ranged from 100ppb-200ppb and milled rice concentration range was from 6ppb-90ppb (Webber *et al.*, 2011) [48]. The change in concentration of aromatic compound in scented rice may be due to temperature factor and late harvesting (Itani *et al.*, 2004) [41] and cultural practice (Prodhan *et al.*, 2020) [11]. Besides the major aromatic component 2AP, other scented compounds were also detected. These include Ethane, 1-isothiocyanato-2-methoxy (fruity smell), Dimethyl ether (sweet smell), Formic acid, 1-methylethyl ester (ethereal odour), Alanine (umami smell), and Boric acid trimethyl

ester (sweet odour) (Fig 5: Table 3). The results surpass the findings of Hinge *et al.* (2016) [45], who identified 88 scented compounds. The present analysis of the resulting scented compounds reveals a completely five new group of scented compounds found in the studied indigenous landraces of Odisha. The high protein contents are the cause of low aroma (Champagne *et al.*, 2007; Champagne, 2008; Prodhan *et al.*, 2020) [49, 50, 11]. So nutrient and aromatic compounds may biosynthetically correlate.

Table 2. PCA loading of nutrient characters.

	PC 1	PC 2	PC 3	PC 4	PC 5	PC 6	PC 7
A	0.442	0.323	-0.359	-0.183	-0.217	0.700	-0.033
B	-0.396	0.534	0.253	-0.151	-0.157	0.077	0.664
C	0.316	0.418	-0.122	0.393	-0.529	-0.520	-0.076
D	0.612	-0.260	-0.011	0.096	0.267	-0.132	0.678
E	0.294	0.374	0.159	-0.679	0.322	-0.366	-0.222
F	0.026	0.469	0.105	0.558	0.641	0.160	-0.142
G	0.293	-0.092	0.869	0.081	-0.251	0.239	-0.152
Eigenvalue	1.708	1.604	0.978	0.905	0.801	0.622	0.382

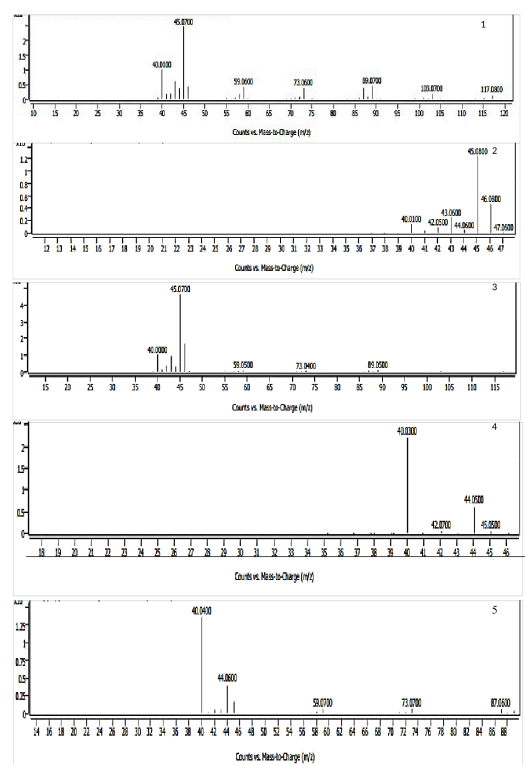


Figure 5. Mass fragmentation pattern of scented compounds detected by GCMS

1-Ethane, 1-isothiocyanato-2-methoxy-, 2-2-acetyl-1-pyrroline, 3- Dimethyl ether, 4- Formic acid, 1-methylethyl ester, 5- Alanine, 6- Boric acid trimethyl ester, 7- Acetone.

Quantification of 2AP

The concentration range, particularly the high value of 0.99 ppm in Thakurbhog and the lower value of 0.14 ppm in Dhusara, corroborates findings from other researchers, who often find substantial variability in 2AP levels among aromatic cultivars. For example, studies have shown that some landraces can exhibit concentrations exceeding 2 ppm, while others may fall below 0.1 ppm. Moreover, the coefficient of variation of 24.03% you reported indicates a moderate level of variability, which is consistent with findings reported in other studies, where the genetic diversity of rice landraces resulted in significant differences in aromatic compound profiles. The observation that 75% of the aromatic landraces had a concentration around 0.28 ppm reflects a trend noted in previous research, where a large proportion of aromatic rice varieties tend to cluster within specific ranges of 2AP concentration. The findings regarding 2-acetyl-1-pyrroline (2AP) concentration in scented rice landraces align with the body of research on aromatic compounds in rice. Studies conducted by various scientists have consistently identified 2AP as a significant contributor to the characteristic aroma of rice varieties. For instance, a notable study by Septiningsih *et al.* (2009) [51] reported similar variations in 2AP levels across different rice varieties, emphasizing the genetic basis for these differences.

Table 3. Scented compounds obtained from aromatic landraces by GCMS analysis.

Sl No.	RT (min)	Chemical name	Chemical group
1	2.547	Ethane, 1-isothiocyanato-2-methoxy-	Alkane
2	2.570	Dimethyl ether	Ether
3	2.570	Formic acid, 1-methylethyl ester	Carboxylic acid
4	1.406	Alanine	Aliphatic amino acid
5	10.152	Boric acid trimethyl ester	Ester

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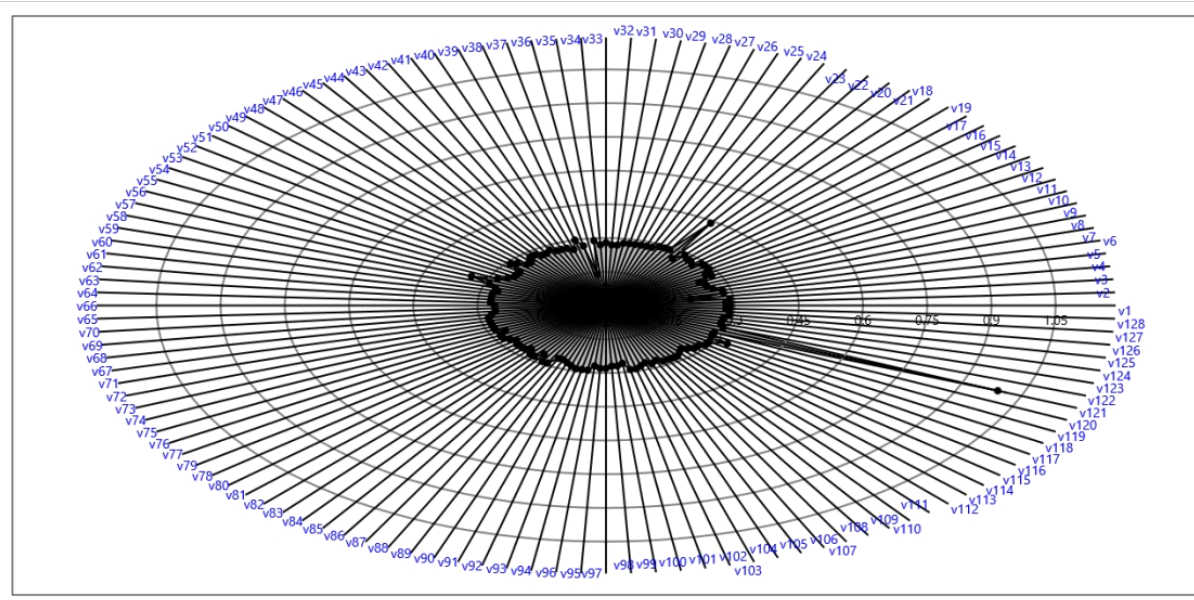


Figure 6. Radar graph showing 2AP concentration (ppm) among different aromatic landraces

Table 4. Summary statistics of 2AP

Number	Minimum	Maximum	Sum	Mean	Std. error	Variance	Stand. dev	Median	25 percentile	75 percentile	Coeff. var
128	0.14	0.99	36.02	0.28	0.01	0.00	0.07	0.28	0.27	0.28	24.03

Conclusion

The present research finding on the nutritional and aromatic qualities of various rice landraces, focusing the major macronutrients such as protein, fat and carbohydrates as well as micronutrients like zinc and iron. The results show that protein content varies among the landraces as Kalajeera having the highest at 9.99%. The average starch content ranges from 66.9% to 91.89% affecting the stickiness of cooked rice. Crude fiber levels are lower than some prior studies ranging from 0.46% to 0.99%. The result reveals a significant correlation between protein and other nutrients that indicates interdependence among these traits. The finding also identifies aromatic compounds using GCMS with 2-Acetyl-1-pyrroline (2AP) being predominant. The concentration of 2AP varies significantly across landraces predominant its importance in the aroma profile of rice which provides an in-depth understanding of the nutritional composition and aromatic characteristics of rice landraces. The positive significant correlations identified suggest that certain nutrient traits can influence each other and they may be beneficial for breeding programs aimed at enhancing both nutritional and aromatic qualities in rice. The detection of a diverse range of aromatic compounds particularly 2AP underscores the genetic diversity and culinary potential of these landraces facilitating for further exploration into their breeding and processing for improved rice varieties.

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Conflict of interest

- The author declares that there is no conflict of interest.

References

- Smith J. Asia's role in aromatic rice production. *Journal of Agricultural Research*. 2020.

- Johnson R. The impact of climate on rice production in Asia. *Agricultural Sciences*. 2019.
- Lee C, Chen H. Economic contributions of aromatic rice in Asia. *Journal of Agricultural Economics*. 2021;12(4):78-89.
- De Candolle A. Origin of cultivated plants, International scientific series vol. XLIX. London: Kegan Paul Trench & co. 1886:376-384.
- De Candolle A. Origin of Cultivated Plants. Kegan Paul, Trench & Co. 1886.
- Dixit S, Singh A, Kumar A. Rice landraces: A valuable genetic resource for future rice improvement. *Journal of Plant Breeding and Crop Science*. 2013;5(3):33-39.
- Rao ES, Reddy PR. Agro-morphological characteristics of rice landraces in India. *Indian Journal of Plant Genetic Resources*. 2006;19(1):1-5.
- Hossain M, Singh AK, Sharma N. Evaluation of aromatic rice landraces using sensory methods and molecular markers. *Rice Science*. 2020;27(1):1-10.
- Panda S, Mohanty S, Nayak S. Proximate composition and aroma evaluation of rice landraces in Odisha. *International Journal of Food Science and Nutrition*. 2020;5(2):45-
- Chaudhary RC, Tran DV. Specialty rices of the world – a prologue. In: Chaudhary RC, Tran DV, editors. *Specialty Rices of the World: Breeding, Production, and Marketing*. FAO, Rome, Italy; and Oxford IBH Publishers, India. 2001:3–14.
- Prodhan ZH, Qingyao S. Rice Aroma: A Natural Gift Comes with Price and the Way Forward. *Rice Science*. 2020;27(2):86-100.
- Singh RK, Singh US. Genetic diversity in rice landraces of India. *Indian Journal of Genetics and Plant Breeding*. 2005;65(1):1-8.
- Sompong R, Siebenhandl-Ehn S, Linsberger-Martin G, Berghofer E. Physicochemical and antioxidative properties of red and black rice varieties from Thailand, China and Sri Lanka. *Food Chemistry*. 2011;124(1):132-140.
- Resurrection AP, Omoaka JB, Yamazaki T. Nutritional content and distribution in milling fractions of rice grains. *Journal of the Science of Food and Agriculture*. 1979;30:475–481.

15. Masniawati A, Marwah Asrul NA, Johannes E, Asnady M. Characterization of rice physicochemical properties local rice germplasm from Tana Toraja regency. *Food Research*. 2018;2(6):487-493.
16. Juliano BO, Bechtel DB. The rice grain and its gross composition. In: *Rice Chemistry and Technology* (2nd ed.). St. Paul, MN: AACC International, Inc; 1985.
17. Anjum FM, Pasha I, Anjum FM, Anwar Bugti M, Butt MS. Mineral composition of different rice varieties and their milling fraction. *Pakistan Journal of Agricultural Science*. 2007;44(2):332-336.
18. Verma DK, Srivastav PP. Proximate composition, mineral content and fatty acid profile of traditional and improved varieties of rice (*Oryza sativa* L.) genotypes. *International Journal of Current Microbiology and Applied Sciences*. 2017;6(4):345-353.
19. Buresova I, Sedlackova I, Famera O, Lipavsky J. Effect of Growing Conditions on Starch and Protein Content in *Triticale* Grain and Amylose Content in Starch. *Plant Soil and Environment*. 2010;56(3):99-104.
20. Eggum BO, Juliano BO, Maningat CC. Protein and Energy Utilization of Rice Milling Fractions by Rats. *Qualitas Plantarum Plant Foods for Human Nutrition*. 1982;31(4):371-376.
21. Singh G, Singh SS, Bhagat BC. Genetic divergence analysis in rice bean. *Indian Journal of Genetics*. 1998;58(1):101-105.
22. Chen R, Ersi K, Yang J, Lu S, Zhao W. Validation of five global radiation models with measured daily data in China. *Energy Conversion and Management*. 2004;45:1759-1769.
23. Cameron DK, Wang YJ. A better understanding of factors that affect the hardness and stickiness of long-grain rice. *Cereal Chemistry*. 2005;82(2):113-119.
24. Rohman A, Sakti MH, Penggalih T, Setyaningrum D. Rice in health and nutrition. *International Food Research Journal*. 2014;21(1):13-24.
25. Wang R, Buresh R, Kam SP. Rice farming for sustainable resource use. Paper presented at the Workshop on Sustainable Use of Agricultural Resources and Environment Management with Focus on the Role of Rice Farming, Tokyo, Japan. 2004.
26. Oko AO, Ubi BE, Efisue AA, Dambaba N. Comparative analysis of the chemical nutrient composition of selected local and newly introduced rice Varieties grown in Ebonyi state of Nigeria. *International Journal of agriculture Science*. 2012;2(2):16-23.
27. Subudhi HN, Meher J, Singh ON, Sharma SG, Das S. Grain and food quality traits in some aromatic long and short grain rice varieties of India. *Journal of Food Agriculture and Environment*. 2013;11(3):1434-1436.
28. Shayo NB, Mamiro P, Nyaruhucha CNM, Mamboleo T. Physicochemical and grain cooking characteristics of selected rice cultivars grown in Morogoro. *Tanzania Journal of Science*. 2006;32(1):29-35.
29. Oko AO, Onyekwere SC. Studies on the proximate chemical composition and mineral element contents of five new lowland rice varieties planted in Ebonyi State. *International Journal of Biotechnology & Biochemistry*. 2010;6(6):949-956.
30. Ebuchi OAT, Oyewole AC, Ebuehi OM, Ikanone CE. Effect of cooking and soaking on physical and nutritive composition of indigenous and foreign rice varieties. In *Proceedings of the Annual Conference of the Nigerian Institute of Food Science and Technology*, Badagry Lagos. 2006:66-67.
31. Yadav RB, Khatkar BS, Yadav BS. Morphological, physicochemical and cooking properties of some Indian rice (*Oryza sativa* L.) cultivars. *Journal of Agricultural Technology*. 2007;3(2):203-210.
32. Thomas TS, Caccavale MV, Rahman CHA, Sun Y. Agriculture and Adaptation in Bangladesh: Current and Projected Impacts of Climate Change. *International Food Policy Research Institute*, Washington DC. 2013.
33. Saikia S, Deka Hazarika D, Saikia SD, Mahanta CL. Quality characterization and estimation of phytochemical content capacity of aromatic pigmented and nonpigmented rice varieties. *Food Research International*. 2012;46(1):334-340.
34. Mbatshou V, Mbatshou VC, Dawda S. The Nutritional composition of four rice varieties grown and used in different food preparations in Kassena- Nankana District, Ghana. *International Journal of Research in Chemistry and Environment*. 2013;3:308-315.
35. Yeager S. Fiber-the Ultimate Healer. In: *The doctor's book of food remedies*. 1998.
36. FAO/WHO. Carbohydrates in Human Nutrition: Report of a Joint FAO/WHO Expert Consultation, 14-18 April 1997, Rome. FAO Food and Nutrition Paper No. 66. Rome; 1998.
37. Ibukun E. Effect of prolonged parboiling duration on proximate composition of rice. *Scientific Research and Essay*. 2008;3(7).
38. Diako C, Sakyi-Dawson E, Bediako-Amoa B, Saalia FK, Manful JT. Cooking Characteristics and Variations in Nutrient Content of Some New Scented Rice Varieties in Ghana. *Annals. Food Science and Technology*. 2011;7.
39. WHO F. Energy and protein requirements. Report of a joint FAO/WHO/UNU expert consultation. Geneva, Switzerland: WHO; 1985.
40. Juliano BO. Properties of the rice caryopsis. In: *Rice: Production and Utilization*; 1980:403-437.
41. Itani T, Tamaki M, Hayata Y, Fushimi T, Hashizume K. Variation of 2-acetyl-1-pyrroline concentration in aromatic rice grains collected in the same region in Japan and factors affecting its concentration. *Plant Prod Sci*. 2004;7(2):178-183.
42. Meena RS, Kumar S, Datta R, Lal R, Vijayakumar V, Brtnicky M, Sharma MP, Yadav GS, Jhariya MK, Jangir CK, Pathan SI, Dokulilova T, Pecina V, Marfo TD. Impact of agrochemicals on soil microbiota and management: A review. *Agronomy*. 2020;10(9):1402.
43. Jefferson JN. Rice quality in world markets. In: *Rice Grain Quality and Marketing*. International Rice Research Institute, Los Banos, Philippines; 1985:1-13.
44. Tanchotikul U, Tungtrakul TCY H. An improved method for quantification of 2-acetyl-1-pyrroline, a popcorn-like aroma, in aromatic rice by high-resolution gas chromatography/mass spectrometry/selected ion monitoring. *Journal of Agricultural and Food Chemistry*. 1991;39:944-947.
45. Hinge VR, Patil HB, Nadaf AB. Aroma volatile analyses and 2AP characterization at various developmental stages in Basmati and Non-Basmati scented rice (*Oryza Sativa* L.) cultivars. *Rice*. 2016;9(1):1-12.
46. Buttery RG, Ling LL, Juliano BO. 2-Acetyl-1-pyrroline: An important aroma component of cooked rice. *Journal of Agricultural and Food Chemistry*. 1982;30(2):312-314.
47. Buttery RG, Ling LC, Juliano BO, Turnbaugh JG. Cooked rice aroma and 2-acetyl-1-pyrroline. *Journal of Agricultural and Food Chemistry*. 1983;31(4):823-826.
48. Webber H, Ewert F, Olesen JE, Müller C, Fronzek S, Ruane AC, Bourgault Yan WH, Wang P, Chen HX, Zhou HJ, Li QP, Wang CR, Ding ZH, Zhang YS, Yu S bin, Xing YZ, Zhang QF. A major QTL, Ghd8, plays pleiotropic roles in regulating grain productivity, plant height, and heading date in rice. *Molecular Plant*. 2011;4(2):319-330.
49. Champagne ET. Rice Aroma and Flavor: A Literature Review. *Cereal Chemistry*. 2008;85:445-454.
50. Champagne ET, Bett-Garber KL, McClung AM, Barton MA. Effects of organic fertility management on physicochemical properties and sensory quality of diverse rice cultivars. *Cereal Chemistry*. 2007;84(4):320-327.

51. Septiningsih EM, Pamplona AM, Sanchez DL, Neeraja CN, Vergara GV, Heuer S, Mackill DJ. Development of submergence-tolerant rice cultivars: the Sub1 locus and beyond. *Annals of Botany*. 2009;103(2):151-160.
52. Hossain A, Sarker SSBMMD, Sadat Sajjad MDS, Sultana SB, Rahman IMM, Rahman MR. Advance technological management of intensive rice-wheat systems of South-Asia. In: Barnarjee A, Meena RS, Jhariya MK, editors. *Food and environmental security*. Springer; 2020:1-20.
53. Itani T, Tamaki M, Hayata Y, Fushimi T, Hashizume K. Variation of 2-acetyl-1-pyrroline concentration in aromatic rice grains collected in the same region in Japan and factors affecting its concentration. *Plant Prod Sci*. 2004;7(2):178-183.
54. McCouch SR, Teytelman L, Xu Y, Lobos KB, Clare K, Walton M, Fu B, Maghirang R, Li Z, Xing Y, Zhang Q, Kono I, Yano M, Fjellstrom R, DeClerck G.
55. Schneider D, Cartinhour S, Ware D, Stein L. Development and mapping of 2240 new SSR markers for rice (*Oryza sativa* L.). *DNA Research*. 1997;4(5):307-310.
56. Pradhan SK, Pandit E, Pawar S, Baksh SY, Mukherjee AK, Mohanty SP. Development of flash-flood tolerant and durable bacterial blight resistant versions of mega rice variety 'Swarna' through marker-assisted backcross breeding. *Scientific Reports*. 2019;9:12810.
57. Saikia S, Deka Hazarika D, Saikia SD, Mahanta CL. Quality characterization and estimation of phytochemical content capacity of aromatic pigmented and nonpigmented rice varieties. *Food Research International*. 2012;46(1):334-340.
58. Sompong U, Somta P, Raboy V, Srinives P. Mapping of quantitative trait loci for phytic acid and phosphorus contents in seed and seedling of mungbean (*Vigna radiata* (L.) Wilczek). *Breeding Science*. 2012;62(1):87-92.
59. Vavilov NI. *Origin and Geography of cultivated plant*. Cambridge University press. 1992:498.

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