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Evaluation of different traditional rice landraces for its bioactive compounds

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In recent decades, the medicinal values of traditional landraces have been of great interest and the cultivation is being revamped among the farmers of Tamil Nadu. The present investigation was aimed to analyse the phytonutrients, antioxidants and functional groups among the six traditional land races. Phytochemical analysis revealed that the pigmented traditional landraces of rice possessed more antioxidant properties. The traditional rice varieties, especially *Mapillai samba* was found to be superior in terms of moisture (11.5±0.16%) and total ash (1.71±0.14%), *Kuzhiyadichan* in protein (9.65±0.67%) and fat (2.53±0.17%), *Iluppaipoo samba* in carbohydrate (79.3±1.29) and energy (1525±24.8 kJ). *Kuzhiyadichan* had highest phosphorous (359±24.7), calcium (46.8±3.23), magnesium (135±9.30), iron (5.70±0.39) and zinc (2.70±0.19) content, whereas copper (0.353±0.02), manganese (0.965±0.06) and potassium (296±23.5) content was higher in *Seeraga samba*, *Kichali samba* and *Mapillai samba*, respectively. The studies revealed that *Mapillai samba* got the highest total phenols (39.25±0.88 mg), vitamin E (27.76±2.39), anthocyanins (45.2±0.16) and antioxidant activity (764±21.3) followed by *Iluppaipoo samba* among traditional rice varieties. FTIR analysis revealed the distribution of biochemically different phenols, carbohydrates, hydroxyl and amide groups. Traditional landraces can be used as a source of antioxidants and nutraceuticals. This finding confers new facet in rice breeding to develop a nutraceutical rich rice and to enhance the farmers production in order to meet the demand of food-based medicines.

Keywords: Antioxidants, FTIR, Functional groups, Phytonutrients, Rice landraces

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Tamil Nadu is a storehouse of enormous traditional rice varieties and the name "Rice Granary of South India" has been conferred to the same. Currently about 400 traditional landraces of rice are cultivated organically and conventionally in the state[1]. These varieties possess good medicinal values and are being utilised by the local farmers, traditional medical practitioners for the ailment of various malnutrient diseases. For instance, *Mapillai samba* is given to the groom for enhancing the fertility[2]. *Poongar* is offered to the girls who attained puberty for the relief of reproductive system related ailments, whereas, *Iluppaipoo samba* preferred by the women for gynaecological issues in the Thanjavur region of Tamil Nadu. *Kuruvi Kar* is eaten by the village people for its health advantages and immunity developments[3]. *Navara* is consumed to treat patients suffering from neurotic disease.

These traditional landraces possess different colours that are considered as a treasure of health benefits when used as brown rice. This pigmented landraces are composed of more mineral nutrients, vitamins and dietary fibre that could contribute to human health system[4]. Equivalently, fibre present in the coloured rice indirectly promotes the cardiovascular health[5]. Antioxidants present in the coloured rice are reported to reduce the risk of heart diseases, cancer and other chronic diseases[6]. Nowadays, attention has been paid to the use of local landraces by the consumers that contain hydrophilic phenolic compounds, including anthocyanins and proanthocyanidinsin differential concentrations[7]. Phenolic compounds are acts as antioxidants and reduced risk of chronic diseases[8,9]. Hence, it put forth the need of the hour for conservation of these medicinal value rich varieties for future pharmacological use.

The study on determination of functional groups in traditional landraces of Tamil Nadu by FT-IR

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technique is dearth. The main aim of this investigation was to use fast FTIR measurement for assessing the antioxidant capacity of functional groups having great significance in the field of pharma, Siddha and Ayurveda industry.

Materials and Methods

Rice samples

Traditional rice landraces were collected from local farmers of Cauvery Delta region of Tamil Nadu, India during 2020. These varieties were authenticated by the Plant Breeder, Department of Plant Breeding and Genetics, Anbil Dharmalingam Agricultural College and Research Institute, TNAU, Trichy. The landraces used in the present investigation was given in Table 1 and Figure 1. Traditional landraces were cleaned for dirt and other foreign materials, then dehusking of all the landraces were done manually and fine powdered for preparation of extracts.

Table 1 — List of different landraces

Landraces	Grain colour
Mappillai Samba	Red
Kichali Samba	Red
Seeragasamba	White
Illupaipoo samba	Brownish black
Kuliyadichan	Red
Poongar	White

Proximate analysis

AOAC[10] standard methods were used to analyse the moisture, crude protein, fibre, fat and ash. Starch was determined by difference. Carbohydrate (%) = 100% - (% moisture + fat + protein + ash), whereas gross energy was drawn from the formula adopted by Ekanayake *et al*.[11].

Mineral analysis

Rice samples were finely ground and used for estimating nutrient contents. Mineral nutrients were analysed by following the standard procedures[12]. Each 0.5 g of the landrace was predigested overnight using 10 mL of triple acid mixture (HNO_3: H_2SO_4: $HClO_4$) in the ratio of 9: 4: 1 in digestion tubes. Then digestion tubes are heated up to 260°C until the solution became clear. After cooling the sample to room temperature, the tubes were filled to 20 mL of Millipore water. Volume was made up to 100 mL and is filtered through Whatman No. 1 filter paper. Aliquots were analysed in Atomic Absorption Spectrometer using the method adopted by Chen *et al.*[13].

Solvent extract for analysis

Ten grams of powdered rice was mixed with 50 mL of acidified methanol for extraction in an electrical shaker (at 30°C for 8 h) in the acidified methanolic extract was revolutioned at 1000 xg for 15 min in a centrifuge and the supernatant was stored at 4°C for further antioxidants analysis.

Fig. 1 — Photographs of different landraces

Total phenolic content

Modified Folin-Ciocalteu method was adopted for determining the total phenolic content of rice landraces[9]. Briefly, an aliquot of 200 µL solvent extract of rice was added to 1 mL of Folin–Ciocalteu reagent and diluted with 10 mL of water and shaken vigorously. One ml of 10% Na_2CO_3 was added to the above mixture and the final volume was made up to 5 mL with distilled water which was left at room temperature for 2 h. A UV- Vis Spectrophotometer (UV-1800, Perkin Elmer) was used to measure the absorbance at 765 nm and the unit was mg gallic acid equivalents per g of rice extract.

Total flavonoid content

Methanolic extract of landrace (250 µL) was taken along with 1.25 mL of distilled water +75 µL of 5% $NaNO_2$ solution. The was left under room temperature for 6 min followed by 150 µL of 10% $AlCl_3$ was added. Then 0.5 mL of 1 M NaOH was added after resting this mixture for 5 min. Vigorous shaking was given to this solution and the absorbance was readat 510 nm. The unit was mg catechin equivalents per g of rice[14].

Total anthocyanin content

Modified pH-differential method was adopted for analyzing the total anthocyanin content[15]. The rice extract was mixed with 0.025 M potassium chloride buffer (pH 1.0) and kept under dark for the reactions to get completed (30 min) at the reading was taken at 520 and 700 nm respectively.

Total antioxidant assay

Methanolic extract (0.1 mL) of landrace was mixed with 3 mL of reagent solution (0.6 M sulphuric acid, 28 mM sodium phosphate and 4 mM ammonium molybdate) and incubated at 95°C for 90 C min. Then the mixture was set to cool in the room temperature and reading was taken at 695 nm against a blank. The result was expressed as µM ascorbic acid equivalent (AAE) per 100 g dry weight of the rice flour[16].

FTIR Analysis

The FTIR analysis was performed using a Thermo Scientific FTIR spectrophotometer (Nicolet iS10 series) with smart iTR transmission accessory. Detector used in this was Deuterated Triglycine Sulfate (DTGS) KBr. Attenuated Total Reflection (ATR) technique was used in this spectrometric analysis to identify the functional groups of different landraces by collecting its infrared spectra. The experiment was conducted thrice to ensure the infrared spectra of each investigated landraces. The observed spectra are the transmittance of the different inputs versus the wave number in the range of 4000-400 cm^{-1} with a resolution of 4. Thirty six scans were recorded, averaged for each spectrum and corrected against ambient air as a background. Data collection was performed by using the OMNIC software.

Statistical analysis

The study was carried out in a completely randomised block design with three replicates. IBM SPSS Statistics 25 (IBM, Inc., Armonk, NY, USA) was used for all the statiscal analysis. The results were expressed as mean of standard error (SE) for three replicates. Significant differences between means were identified using Fisher least significant differences (LSD) at p=0.05. Subsequently, all relationships between phytonutrients were evaluated using Pearson's correlation tests. The FTIR transmission data was imported to Microsoft Excel and processing was done using OriginPro 2019 software.

Results and Discussion

Proximate composition

The proximate analysis (moisture, ash, fat, protein, fibre, carbohydrate and energy) of rice landraces is given in Table 2. The moisture content was significantly different (p<0.05) between the rice landraces. As seen from Table 2, the significantly

Table 2 — Proximate composition of different rice landraces

Landraces	Moisture (%)	Total Ash (%)	Total Protein (%)	Total Fat (%)	Dietary Fibre (g)	Carbohydrate (%)	Energy value (kJ per 100 g)
Mappillai Samba	11.5±0.16^{ab}	1.71±0.14^{a}	7.17±0.57^{b}	1.94±0.15	1.68±0.13	77.7±1.07	1490±20.4
Kichali Samba	9.8±0.05^{c}	0.84±0.05^{b}	7.91±0.47^{ab}	1.09±0.06	0.03±0.002	80.4±0.43	1516±8.04
Seeragasamba	11.8±0.15^{a}	0.41±0.04^{c}	7.04±0.77^{b}	0.75±0.08	BDL	80.0±0.99	1481±18.3
Illupaipoo samba	9.8±0.16^{c}	0.48±0.02^{c}	9.14±0.35^{a}	1.29±0.05	0.04±0.004	79.3±1.29	1525±24.8
Kuliyadichan	11.2±0.78^{ab}	1.65±0.11^{a}	9.65±0.67^{a}	2.53±0.17	1.71±0.07	74.9±1.31	1508±18.4
Poongar	10.5±0.05^{bc}	0.62±0.04^{bc}	8.18±0.51^{ab}	1.34±0.08	BDL	79.3±0.37	1512±7.11

Data are the mean values of three replicates with±standard error. Means followed by the same letter within each column are not significantly different at 5% level.

higher moisture content was observed in *Seeraga samba* (11.8±0.15%) which was statistically comparable with *Mapillai samba* (11.5±0.16%). The lowest content (9.8±0.16%) was recorded in *Iluppaipoo* and *Kichili samba*. All landraces were found to express the acceptable limit (12%) of moisture content for long term storage of rice. This variation might be due to genetic nature and the prevailing climatic parameters in which they are cultivated. Moisture is reported to influence the milling characteristics and taste of rice[17].

The fat content ranged from 0.75 to 2.53% and significant variation was found among the landraces ($p<0.05$). The high fat content was reported for *Kuzhiyadichan* and lowest for *Seeraga samba*. The difference in fat content of rice landraces may be due to oxidation of unsaturated fat by atmospheric oxygen[18]. Rice fat is a worthy source of linoleic acid and other essential fatty acids, which is present in the aleurone layer and bran mainly as lipid bodies. Rice fat is devoid of cholesterol[19].

Protein content of rice decides the eating and nutritional quality of rice after starch, which significantly differed ($p<0.05$) among the studied landraces. The highest percentage of protein was found in *Kuzhiyadichan* (9.65±0.67%) which was statistically comparable with *Iluppaipoo samba* (9.14±0.35%) and the lowest content of protein was observed in *Seeraga samba* (7.04±0.77%). Rice protein is superior to all other cereals due to the presence of lysine. The difference in protein content of landraces might be ascribable to the climatic conditions in which they grow and the agronomic practices which was consistent with the findings of Buresova *et al.*[20]. Improvement in rice protein by agronomic management would be very interesting where rice is the staple food and nutritional quality is considered. The variation might be preferable to the pigmentation nature of different landraces in genetic makeup and by the presence of essential minerals, which was in line with the findings of Oko *et al.*[21].

The ash content ($p<0.05$) varied significantly between different rice landraces and ranges from 0.41 to 1.71%. Significantly highest ash content was found in *Mapillai samba* (1.71±0.14%) which was statistically at par with *Kuzhiyadichan* followed by *Kichili samba*, whereas *Seeraga samba* had the lowest (0.41±0.04%). Amount of carbohydrate in all landraces (> 70%) was high and apparently is not surprising as rice is good source of carbohydrate. Energy value indicates the quantity of energy obtained from food after cellular respiration. In this study, *Iluppaipoo samba* was reported to have higher energy per 100 g among others (1525±24.80 kJ).

The Landrace "*Kuzhiyadichan*" had very high fibre content, followed by "*Mapillai samba*", while "*Kichili samba*" and "*Iluppaipoo samba*" had the least amount of fibre. In *Poongar* and *Seeraga samba* the fibre content was below detectable level. The crude fibre content affects the rice digestibility whereby high content of crude fibre in rice lowers its digestibility. Crude fibre has important physiological functions like retention of food in the intestine for a longer period of time to facilitate digestion, retention of moisture and most importantly excretion.

Mineral composition

The mineral composition of various landraces was evaluated and the corresponding data are depicted in Table 3 with significant difference ($p<0.05$). Among all the minerals, the phosphorus content (116.5 to 358.7 mg/ 100 g) was highest, followed by potassium (84.8 to 295.7 mg/ 100 g), magnesium (33.25 to 134.9 mg/ 100 g), calcium (21.69 to 46.83 mg/ 100 g), iron (2.9 to 6.6 mg/ 100 g), zinc (1.3 to 2.7 mg/ 100 g), manganese (0.273 to 0.965 mg/ 100 g) and copper content (0.212 to 0.373 mg/ 100 g). Distinctively high P, K, Ca and Mg were observed in *Mapillai samba*

Table 3 — Mineral composition of different rice landraces

Landraces	Mappillai Samba	Kichali Samba	Seeraga samba	Illupaipoo samba	Kuliyadichan	Poongar
Potassium (mg per 100 g)	$296±23.5^{a}$	$182±10.8^{bc}$	$219±23.9^{b}$	$85±3.29^{d}$	$276±19.0^{a}$	$135±8.45^{cd}$
Phosphorous (mg per 100 g)	$328±26.1^{a}$	$146±8.7^{c}$	$255±27.7^{b}$	$116±4.5^{c}$	$359±24.7^{a}$	$226±14.2^{b}$
Calcium (mg per 100 g)	$42.2±3.35^{ab}$	$28.3±1.69^{cd}$	$36.7±3.99^{bc}$	$21.7±0.84^{d}$	$46.8±3.23^{a}$	$29.8±1.86^{cd}$
Magnesium (mg per 100 g)	$120±9.56^{a}$	$41±2.44^{b}$	$114±12.4^{a}$	$33±1.29^{b}$	$135±9.30^{a}$	$116±7.27^{a}$
Iron (mg per 100 g)	$5.40±0.43^{b}$	$2.90±0.17^{d}$	$4.10±0.45^{c}$	$3.20±0.12^{cd}$	$5.70±0.39^{ab}$	$6.60±0.41^{a}$
Zinc (mg per 100 g)	$2.10±0.17^{b}$	$1.30±0.08^{d}$	$1.90±0.21^{bc}$	$1.60±0.06^{cd}$	$2.70±0.19^{a}$	$1.50±0.09^{cd}$
Manganese (mg per 100 g)	$0.273±0.02^{d}$	$0.965±0.06^{a}$	$0.781±0.08^{bc}$	$0.88±0.03^{ab}$	$0.921±0.06^{ab}$	$0.642±0.04^{c}$
Copper (mg per 100 g)	$0.251±0.02^{cd}$	$0.264±0.02^{cd}$	$0.373±0.04^{a}$	$0.30±0.01^{bc}$	$0.353±0.02^{ab}$	$0.212±0.01^{d}$

Data are the mean values of three replicates with±standard error. Means followed by the same letter within each row are not significantly different at 5% level.

and this was comparable with *Kichili samba* whereas, significantly high Zn was found in *Kuzhiyadichan*, Cu (*Seeraga samba*), Mn (*Kichili samba*) and Fe (*Poongar*). The result of the present investigation unveiled that the mineral composition were different for the landraces which mainly determine by genetic makeup and degree of milling process. Pigmented and non-pigmented landraces contains considerable amounts of magnesium that prevents the risk of heart attacks[22]. Its performs a crucial role in regulating blood pressure and sodium balance. High potassium, calcium and magnesium could be helpful in improving muscle activity in patients suffering from muscle wasting. Zinc is essential for enzymatic processes, iron induces the production of haemoglobin and phosphorus maintains internal water balance. Deficiency of these elements may lead to the severe health issues such as diarrhoea, anaemia, weight loss and infection. For the normal functioning of brain and nerves, manganese is essential and copper for enzyme production. The minerals rich landraces are considered as a cost-effective and promising alternative for the alleviation of malnutrition and other health related problems.

Antioxidants

Significant variations were observed in vitamin E content which ranged from 10.68 to 27.76 µg/g for the six landraces studied (Fig. 2). *Mapillai samba* showed the maximum value for vitamin E content (27.76±2.39 µg/g) which was statistically comparable with *Iluppaipoo samba* (26.15±1.86 µg/g). Coloured landraces showed significant ($p<0.05$) variation for vitamin E whereas, no significant differences fornon-coloured ones. In general, higher vitamin E content is

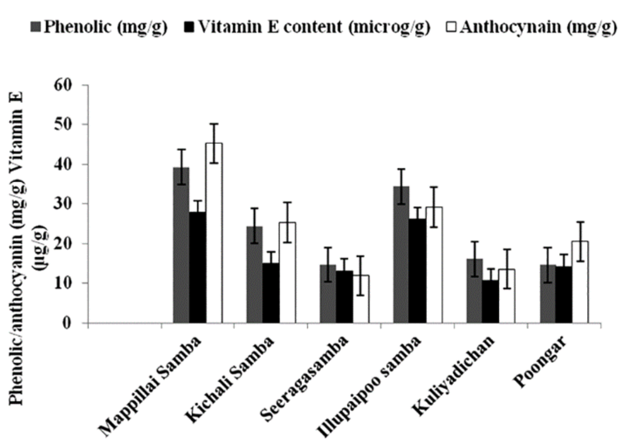

Fig. 2 — Total phenolic, vitamin E and anthocyanin content of different landraces

closely related to coloured landraces. Variation in vitamin E content among the landraces might be attributed to the climate and soil factors and is consistent with previous findings of Goufo and Trindade[23]. Vitamin E inhibits the production of reactive oxygen species and improves cardiovascular functions[24]. This vitamin E rich traditional landraces may be used in the preparation of medicines for curing various ailments.

The landraces possessed significant difference ($p<0.05$) for phenolic content and the highest content was noticed in *Mapillai samba* (39.25±0.88 mg/100 g) which was comparable with *Iluppaipoo samba* (34.35±0.56 mg/100 g) and the lowest with *Poongar* (14.61±0.53) mg/100 g (Fig. 2). Variations in phenolic compound might be owed to pericarp colour as demonstrated by Tian *et al.*[25]. From this study it is apparently evident that the highest phenolic content of these landraces are due to the different pericarp colour. Apart from this genetic makeup, milling and polishing process also influences the phenolic content. Phenolics are a group of natural antioxidants that has been paid significant attention due to their pharmacological roles such asoxidative stress reduction and prevention of cancer[26,27]. Phenols control the blood lipids and related diseases, which may help in the prevention of cardiovascular problems and prevention of the complications of diabetes[28].

Total anthocyanin content was significantly ($p<0.05$) different among the rice landraces and the highest was found in *Mapillai samba* 45.20±0.16 mg/100 g followed by *Iluppaipoo samba* 29.15±0.58 mg/100 g. The lowest was related to *Kuzhiyadichan* 13.50±0.69 mg/100 g (Fig. 2). Present study agrees with the literature, that the coloured landraces possess high anthocyanin content compared to non-pigmented ones[29]. Anthocyanins present in red rice have properties that can help in weight management and reduce allergy, anticancer, hypoglycaemic anti-inflammatory effects and highly virulent in reducing cholesterol levels of human body[30].

Statistically significant values ($p<0.05$) were observed in the total flavonoid contents of all the analysed landraces (Table 4). Among all the rice landraces, total flavonoid content ranged from 2.99±0.09 to7.81±0.55 mg/100 g, with the lower values from *Poongar*, while the higher values from *Iluppaipoo samba*. According to Furukawa *et al.*[31] pigmentation of rice has a direct relation to the accumulation of anthocyanin. This was apparently confirmed in the present study that white rice had less flavonoid content than coloured landraces. The wide diversity in the flavonoid content is due to genetic character of wide landraces used. Flavonoids have an excellent antioxidant potential and are the most ubiquitous groups of plant secondary metabolites[32]. Increased consumption of flavonoid compounds inhibits proliferation in numerous kinds of cultured human cancer cell lines, anti-inflammation, antimicrobial agents and reduce in various forms of reactive oxygen species[33].

The total antioxidant activity ranged from 321 to 764 µM AAE/100 g among the rice landraces (Table 4). The antioxidant activity of the rice landrace was found to be higher in *Mapillai samba* followed by *Iluppaipoo samba* which was on par with *Seeraga samba* (453±21.2 µM AAE/100 g) while the lowest was related to *Poongar* (321±20.1 µM AAE/100 g). High phenolic content in coloured rice is responsible for more antioxidant activity compared to non-coloured which was also confirmed by the findings of Lee *et al.*[34].

Relationship between the antioxidants

Pearson's correlation coefficient was obtained from bivariate correlation analysis to describe the correlation between the antioxidant activities (Table 5). The results demonstrated that relationship between the antioxidants were positive ($p<0.001$ and $p<0.005$) among the analysed rice landraces. The phenolic contents were highly positive correlated with vitamin E (r=0.953**), anthocyanin (r=0.924**), flavonoid (r=0.978**) and the antioxidant capacity (r=0.856*) among all the rice. This is in agreement with the findings of Oki *et al.*[35]. In general, the traditional landraces possess high antioxidant activity as they are not polished.

Table 4 — Antioxidants and flavonoid content of different landraces

Landraces	Antioxidants activity (µM AAE/100 g)	Flavonoid content (mg/100 g)
Mappillai Samba	764±21.3[a]	7.60±0.65[a]
Kichali Samba	327±19.5[c]	5.06±0.47[b]
Seeragasamba	453±21.2[b]	3.57±0.21[c]
Illupaipoo samba	654±25.4[a]	7.81±0.55[a]
Kuliyadichan	416±22.9[bc]	3.92±0.20[bc]
Poongar	321±20.1[c]	2.99±0.09[c]

Data are the mean values of three replicates with±standard error. Means followed by the same letter within each column are not significantly different at 5% level.

Functional group distribution

FT-IR spectral characterisation of different landraces was illustrated in Figure 3. Thirteen major bands were observed in different wave regions for 10 seed from all the landraces subjected to FTIR. FT-IR was run in the wave number range of 400–4,000 cm^{-1}. Then fingerprint region of 815 and 1130 cm^{-1} (typically reflected in the biochemical composition of rice (proteins, lipids, carbohydrates, polysaccharides and polyphenols). A characteristic peak at 841 cm^{-1} was attributed to C-H bending groups of polyphenols is in accordance with the finding of Schulz and Baranska[36]. The difference in absorbance among the samples deceptively indicates the variation of phenolic content of landraces. In the present work, it was confirmed that the traditional landraces possessed a sufficient amount of phenols. All the landraces showed vibration between 861 and 996 cm^{-1} confirming the presence of $–CH_2OH$ groups of carbohydrates. The strong vibration at 984 cm^{-1} might be due to C-O of C-O-C orα-1,4 glycosidic linkage of C-O-C in starch[37]. The waveleng that 1063 cm^{-1} showed C−O-H bending vibration, while the wave number of 1,130 cm^{-1} was

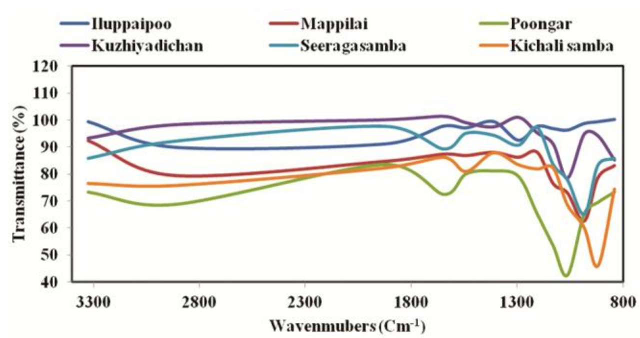

Fig. 3 — Functional group distribution among the rice landraces

Table 5 — Pearson correlation coefficients between antioxidants of different rice landraces

Variables	Phenolic content	Vitamin E	Anthocyanin	Flavonoid	Antioxidants
Phenolic content	1	0.953 **	0.924 **	0.978 **	0.856*
Vitamin E		1	0.892*	0.937**	0.895*
Anthocyanin			1	0.825*	0.748
Flavonoid				1	0.867*
Antioxidants					1

* and ** were significant at 0.05 and 0.01 probability level, respectively.

ascribed to the stretching of C−C and C−O. Existence of C=Ostretching vibration at 1206 cm^{-1} affirms the presence of esters which was also confirmed by Subbu Thavamurugan *et al.*[38]. The band at 1294 cm^{-1} can be ascertained to the vibrations of C-N stretching of aromatic amines. A weak band at 1411 cm^{-1} owing to –CH bending of -CH_2 or asymmetric stretch of -CH_2, while a peak at 1541 cm^{-1} can be attributed to the N-H Bending/C-N stretching mainly from proteins or rice[39]. Strong bands at 1650 cm^{-1} show the characteristics of -COO stretch of carbohydrate group also noted by Fan *et al*.[37]. The band at 1925 cm^{-1} is ascertained to C-H bending of aromatic compounds. The spectrum of 2,916 cm^{-1} was due to CH_2 antisymmetric stretch of methyl groups, mainly from lipids and proteins and these findings are confirmed by Naumann[40]. The distinctive band at 3324 cm^{-1} can be confirmed to the OH Stretching/NH stretching and shows the presence of Amide A protein in the rice.

Conclusion

The results of the present investigation highlighted that good amount of bioactive compounds are present in different landraces. FTIR analysis showed that the rice landraces exhibited various antioxidants and nutrients imputable to the presence of functional groups on their surfaces. These bioactive compounds and functional groups make these traditional varieties imperative in the field of pharmaceutical industries in the preparation of various Ayurvedic and Siddha based medicines. Therefore, these landraces studied can be planned for major rice breeding strategies for their high nutritive, nutraceutical and medicinal values. If the landraces are utilised properly, it can warrant the improvements in overall human health and will sustain balanced nutrition that alleviates the malnutrition issues.

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Conflict of Interest

The authors declare that there is no conflict of interest.

Authors' Contributions

DUN and ES: Conceptualization, DUN: survey, documentation & drafting; DUN and MA: Analysis; ES and MA: review and editing.

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