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FUNCTIONAL GROUP PROPERTIES AND QUANTIFICATION OF MINERAL NUTRIENTS IN TRADITIONAL PADDY CULTIVARS

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Abstract

The functional properties and mineral nutrients of eleven rice cultivars were investigated. Among the cultivars, Mapillai samba, Arupadham kuruvai, and Karuppu kavuni recorded the presence of higher levels of carbohydrate (67.88, 67.47 and 62.30 mg/100g, respectively). Higher levels of fibre of 3.27, 2.61 and 2.36mg/100g were recorded in Kalabath, Poonkar and Sigappu kavuni, respectively. Higher level of protein content of 15.39, 10.80and 9.61 mg/100g, were recorded in Illupaipoo samba, Thooyamalli and Poonkar, respectively. Interestingly, Kalabath recorded more nitrogen (2.52 mg/100g), Mappillai samba recorded more iron (301.70 ppm) and manganese (23.02 ppm), Karunguruvai recorded more phosphorus (0.39%) and magnesium (0.98%), Sugappu kavuni recorded more copper (20.26 ppm), Karunguruvai recorded more potassium (0.41%) and zinc (40.98 ppm). The findings suggested that conventional rice varieties with enhanced functional attributes could support the agricultural community by improving the farming economy while also increasing the health advantages for consumers.

Introduction

For over half of the global population, particularly in Asia, rice is a crucial staple food. India produces 177 million tonnes of rice annually. Rice is cultivated over 44 million hectares, yielding an average of 2.78 tonnes per hectare in India, (Agricultural Statistics 2018). The Green Revolution of the 1960s focused on developing high-yielding rice types that offered greater production, shorter growing seasons and more frequent cropping, allowing two to three harvests within a year (Ashraf and Lokanadan 2017).

Farmers are increasingly realizing that traditional rice varieties possess a valuable genetic resource that enables them to adjust to challenges in climate change (Krishnankutty *et al.* 2021). Lately, traditional rice cultivars have gained popularity in the realm of organic farming. Farmers are motivated to grow these varieties because of the important characteristics of traditional cultivars, including their health benefits, nutritional value, and consumer demand. Traditional rice is loaded with fat, ash, protein, and contains high amounts of calcium, phosphorus, iron, magnesium, potassium, and zinc (Valarmathi *et al.* 2015). Nonetheless, there has been a lack of thorough research on the nutritional content of India's traditional rice varieties. To promote the cultivation of traditional rice in India, it is essential to conduct a systematic study that would highlight the nutritional benefits of these varieties and ensure their competitiveness in the global market (Gopika and Usha 2020).

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To examine the variations in the functional properties of several traditional rice varieties, several procedures have been used. These methods include spectroscopic examination employing atomic absorption spectroscopy, SDS-PAGE, and FTIR spectroscopic analysis (Jamme *et al.* 2008) and several other common approaches (Cubadda *et al.* 2004).

The analysis of primary cell wall properties at the molecular level using Raman spectrometry is potent methods that can supplement data from Fourier transform infrared micro spectroscopy. Additionally, the practical use of infrared for quantitative analysis has substantially expanded because of the sensitivity and accuracy of FTIR detectors and a wide range of software algorithms (Dowell *et al.* 2006). The main objective of the present study was to find out the different functional properties and mineral nutrients of 11 traditional rice cultivars grown in Tamil Nadu.

Materials and Methods

Rice grains were collected from eleven traditional varieties *i.e.*, Arubatham kuruvai, Mappillai samba, Illupaipoo samba, Thanga samba, Poonkar, Karuppu kavuni, Thooyamalli, Sigappu kavuni, Kalabath, Kothamalli samba, and Karunguruvai, popular among farmers in Tamil Nadu (Table 1). The collected paddy grains were washed and stored at room temperature (25-28°C) for use. The prepared rice grain samples were analyzed using the FT-IR (Nicolet iS10 spectrometer) to identify the functional group of each cultivar as per the protocol described by Malik *et al.* (2023).

The collected samples were analysed for total major, secondary, and micronutrients. Total nitrogen (N) was determined by digestion with a diacid mixture (Humphries 1956), total phosphorus (P) by vanado molybdate yellow color method by digestion with a triacid mixture, total potassium (K) by flame photometry using triacid extract, and micronutrients *viz.*, iron (Fe), zinc (Zn), manganese (Mn), and copper (Cu) were analysed by the atomic absorption spectrophotometer method (Lindsay and Norwell 1978).

Results and Discussion

Based on the result of FT-IR functional properties analysis, the presence of an alcoholic group in rice cultivars (Mappillai samba, Illupaipoo samba, Poonkar, Thooyamalli, Sigappu kavuni, Kalabath, Kothamalli samba, and Karrupu kavuni) were shown to have high cellulose and hemicellulose content as compared to other cultivars as reported for paddy straw (Bhattacharyya *et al.* 2020, Giang *et al.* 2020, Thakur *et al.* 2020). The rice cultivars such as Arubatham kuruvai, Sigappu kavuni, Kothamalli samba, Kalabath, and Karrupu kavuni were represented in the same clade due to the expression of similar functional groups properties. While Illupaipoo samba, Thanga samba and Poonkar were occupied in another clade. Among the rice cultivars, Mapillai samba exhibited the presence of more functional groups properties as compared to other cultivars (Fig. 1).

The functional traits of eleven rice cultivars were evaluated in terms of their properties and composition. As shown in Fig. 1, cultivars like Arubatham kuruvai, Sigappu kavuni, Kothamalli samba, Kalabath, and Karrupu kavuni clustered together in the same group due to their expression of comparable functional traits. Conversely, Illupaipoo samba, Thanga samba, and Poonkar were classified into a different group. Results shown in Fig. 2, Mapillai samba exhibited the greatest number of functional properties in comparison to others. The results indicated that Mapillai samba had the highest carbohydrate content, followed by Arupadham kuruvai and Karuppu kavuni and the least in Karunguruvai. Likewise, Kalabath showed the greatest fiber content, trailed by Poonkar and Sigappu kavuni. Concerning protein content, Illupaipoo samba had the highest amount, with Poonkar in second place. Similar views were reported by Gopika and Usha (2020),

Hafeel *et al.* (2020) and Kowsalya *et al.* (2022). Similar results of biochemical properties were recorded by Devraj *et al.* (2020) in Mappillai samba. Mappiai samba is rich in iron and fiber, has a low glycemic index, and is suitable for individuals with diabetes (Rajendran and Chandran 2020).

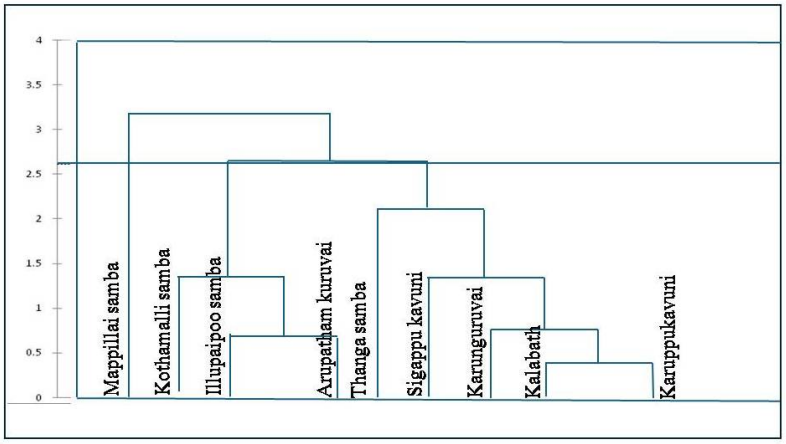

Fig. 1. Dendrogram illustrating the similarity of functional properties among the rice cultivars.

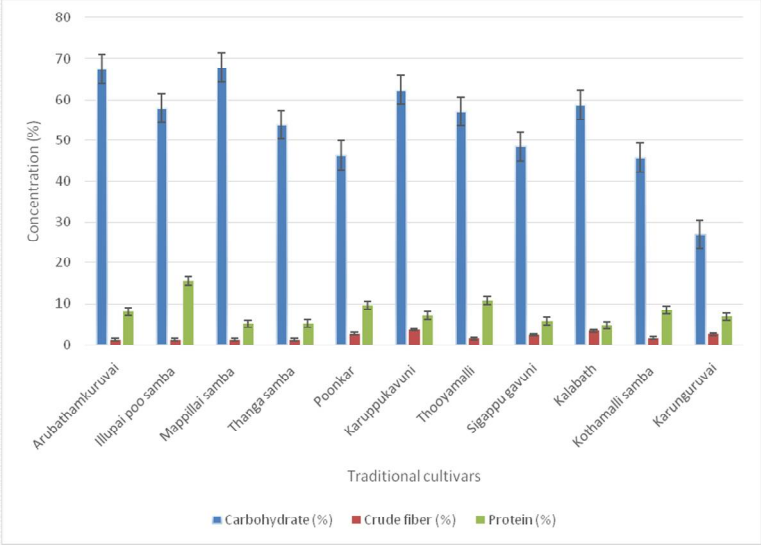

Fig. 2. Concentration of protein, carbohydrate and fibre among the eleven rice cultivars.

The mineral nutrients of various grains were evaluated, and each type has its unique nutritional profile, showing significant differences from one another (Table 1). The findings indicate that Karunguruvai (0.39 mg/100 g), Arupatham kuruvai (0.37 mg/100 g), Mappillai samba (0.31 mg/100 g), and Kalabath (0.31 mg/100 g) have higher phosphorus levels. Karunguruvai (0.41 mg/100 g) and Arupatham kuruvai (0.40 mg/100 g) exhibit greater potassium content. Thanga samba, Poonkar, Mappillai samba, and Kalabath display elevated calcium levels of 1.60, 1.60, 0.96 and 0.96 mg/100 g, respectively. Magnesium levels were relatively consistent

Table 1.Concentration of mineral nutrients in eleven traditional rice cultivars.

Traditional rice cultivars	N (mg/100g)	P (mg/100g)	K (mg/100g)	Ca (mg/100g)	Mg (mg/100g)	Fe (ppm)	Zn (ppm)	Mn (ppm)	Cu (ppm)
Arupathamkuruvai	1.40	0.37	0.40	0.64	0.98	120.80	23.04	13.86	5.64
Mappillai samba	0.39	0.31	0.34	0.96	0.58	301.70	25.00	23.02	4.92
Illupaipoo samba	1.65	0.30	0.36	1.28	0.38	152.04	24.40	17.70	6.30
Thanga samba	1.62	0.11	0.29	1.60	0.38	199.96	30.62	16.08	1.80
Poonkar	0.17	0.17	0.34	1.60	0.19	130.64	29.50	14.80	5.26
Karuppukavini	0.22	0.21	0.33	0.96	0.19	40.50	27.66	16.34	2.34
Thooyamalli	0.17	0.29	0.28	0.96	0.38	55.16	20.00	15.98	9.28
Sigappukavuni	1.90	0.19	0.30	1.28	0.58	104.02	19.78	11.64	20.26
Kalabath	2.52	0.31	0.35	0.96	0.19	100.58	21.96	16.06	4.50
Kothamalli samba	1.85	0.24	0.35	0.64	0.58	112.28	24.42	15.80	2.90
Karunguruvai	0.11	0.39	0.41	0.64	0.58	102.24	40.98	17.28	6.36
Maximum	2.52	0.39	0.41	1.60	0.98	301.70	40.98	23.02	20.26
Minimum	0.11	0.17	0.28	0.96	0.19	40.50	25.00	16.08	1.80
SEd	0.914	0.085	0.044	0.345	0.264	70.176	6.650	3.055	5.989

Table 2.Functional group of different rice cultivars.

Rice cultivar	Aliphatic hydrocarbon	Aliphatic primary amides	Alkyl monosubstituted	Inorganic phosphate	Primary aliphatic alcohol	Aliphatic tertiary amides	Secondary aliphatic alcohol	Furan	Terminal Vinyl olefins	Esters
Arubathamkuruvai	+	-	-	-	-	-	-	-	-	+
Mappillai samba	+	+	+	+	+	-	-	-	-	-
Illupai poo samba	+	-	-	+	-	+	+	-	-	-
Thanga samba	-	-	-	-	-	-	-	-	-	-
Poonkar	-	+	-	-	+	-	-	-	-	-
Karuppukavuni	-	+	-	+	+	-	-	-	-	-
Thooyamalli	+	+	-	+	+	-	-	-	-	-
Sigappukavuni	-	+	-	-	+	-	-	-	-	-
Kalabath	+	+	-	-	+	-	-	+	-	-
Kothamalli samba	+	+	-	-	+	-	+	-	+	-
Karunguruvai	+	+	+	-	+	-	-	-	-	-

+ and - represent the presence and absence of functional group.

(0.58 mg/100 g) in Mappillai samba, Sigappu kavini, Kothamalli samba, and Karunguruvai, while Mappillai samba (301.70 mg/100 g) and Thanga samba (199.96 ppm) had the highest iron content. Thanga samba showed the highest zinc content at 40.98% compared to the other varieties. Mappillai samba (23.02 ppm), Illupaipoo samba (17.70 ppm), and Karunguruvai (17.28 ppm) registered higher manganese levels, while Sigappu kavuni had the greatest copper content at 20.26 ppm.Thooyamalli and Thanga samba are known to increase human life expectancy and have a high concentration of protein, fat, and total ash. It is also rich in iron, magnesium, zinc, phosphorus, potassium, calcium, and phosphorus (Balasubramanian *et al.* 2019). The nutritional content of rice is affected by the genotype, the soil, and the environmental conditions during cultivation, in addition to the conditions of postharvest processing and storage, as well as the extent of milling, which impacts the nutritional quality for end use.

Karuppu kavuni is rich in fat, ash, and protein, and has a high concentration of calcium, phosphorus, iron, magnesium, potassium, and zinc (Valarmathi *et al.* 2015). Sigappu kavuni is abundant in fat and total ash, and as noted by Kalaivani *et al.* (2020). It also contains high levels of iron, calcium, magnesium, potassium, zinc, and phosphorus. Kothamalli and Kalabath are high in fat and protein, containing substantial amounts of mineral content (Majumder *et al.* 2019). Data on grain protein, crude fat, and fiber levels in both traditional and improved rice varieties show significant variations and inconsistencies both within and across these varieties (Jayadewa *et al.* 2023). Subbu Thavamurugan *et al.* (2023) discovered highest protein content in Kattuyanam.

According to the analysis of functional properties, rice cultivars Mappillai samba and Kothamalli samba exhibited a higher concentration of bioactive compounds due to the presence of an alcoholic group compared to other cultivars. The rice varieties Karunguruvai, Kalabath, and Kothamalli samba clustered together in the same clade because they displayed similar functional group properties. While Karuppu kavuni and Thooyamalli were engaged in a different lineage, Mapillai samba stood out among the rice varieties due to its higher presence of functional group properties in comparison to other cultivars (Table 2). Functional groups are primarily associated with traditional rice and play a crucial role in promoting overall health. The nutrients and phytochemicals present in rice are likely comparable to those found in other grain varieties. With sustained dietary consumption, bioactive compounds may provide protection against illnesses and adversely impact the human immune system. It promotes the immune system and bone health, slows the aging process, and offers protection against chronic illnesses (Dewan *et al.* 2023). Mappiai samba is abundant in iron and fiber, features a low glycemic index, and is appropriate for those with diabetes. The Poonkar variety provides antiviral and antioxidant properties (Rathna Priya *et al.* 2019).

It was concluded from the study that the functional group properties identification in the traditional paddy cultivars may be useful to explore therapeutic value and to discover functional compounds and will also be helpful to design drugs for medical treatment.

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