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Agricultural Remedy for Nutritional Malady: The Significance of Traditional Rice Varieties in Addressing Malnutrition in Rice Growing Tracts of Kerala, India

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ABSTRACT

Background: Rice is the staple food of more than half of the world population. Incidence of micronutrient deficiency disorder in rice consuming regions is a growing concern. This paper explores the potential of traditional rice varieties for addressing hidden hunger by assessing their nutritional value and chronicling the traditional wisdom and culinary practices associated with rice.

Methods: Food and nutritional benefits of eight traditional rice varieties were analysed in CFTRI, Mysore during the year 2022 using proximate analysis and focussed group discussion were conducted among traditional rice farmers of Wayanad to elicit ethnic knowledge and practices related to the use of rice as a nutraceutical.

Result: Nutritional analysis of traditional rice varieties (TRVs) revealed that they are good sources of micronutrients compared to the high yielding polished rice, which are consumed widely. TRVs are rich sources of calcium [85.63 mg 100 gm^{-1}], iron [5.66 mg 100 gm^{-1}], zinc [2.90 mg 100 gm^{-1}] and potassium [221.87 mg 100 gm^{-1}], which are available at significantly greater concentrations than the polished MRV available in Kerala for consumption. The study found that cultivation of TRVs is now mostly confined with indigenous farmers in the study area, as their culture and traditions are interlinked with rice cultivation. The culinary traditions and traditional wisdom associated with the use of TRVs contribute significantly for the conservation TRVs in Wayanad. People in low-income categories who cannot afford diverse food groups in their diet in rice-growing areas are more vulnerable to malnutrition-related health disorders. Since rice is the staple food of the rural poor, efforts to make staple foods more nutritive or increased consumption of TRVsare effective and low-cost strategies for reducing malnutrition in the country.

Key words: Fortification, Malnutrition, Traditional knowledge, Traditional rice.

INTRODUCTION

Rice is a staple food consumed by at least 33 developing countries, providing 27% of dietary energy, 20% of dietary protein and 3% of dietary fat (Kennedy *et al*., 2003). Ironically, in these regions of developing countries, rice is the prime source of nutrition and is the hardest hit by major public health challenges, including malnutrition, infectious diseases and chronic diseases (Dipti *et al*., 2012). Protein energy malnutrition, iron, iodine and vitamin A deficiency are the most common nutritional problems in rice-consuming states (Kennedy *et al*., 2003). Addressing malnutrition issues among low-income households in rice-growing areas is challenging because rice is a staple food. Ensuring that consumed rice has adequate nutrients for a healthy life is a potential strategy for reducing nutritional issues in rice-growing areas (Kennedy *et al*., 2003). Rao and Swaminathan (2017) suggested that malnutrition can be addressed through the cultivation and consumption of naturally bio-fortified TRVs.

Rice is an indispensable cereal for people in Kerala. The cultivation of rice in Kerala dates back to 3000 BC (Manilal, 1991). The area under rice cultivation, traditional rice varieties in particular is showing a declining trend since the mid-1970s. The coverage of high-yielding variety (HYV) rice in gross rice cropped areas was only 18.17% in 1970-71, which increased to 96.74% in 2020-21 (GoK, 2023). The changes in the area under rice cultivation over several decades indicate that there has been a sharp decline in the area under cultivation for both traditional and HYV rice in the state and the rate of decline in the area under traditional rice cultivation was more pertinent, as it has left less than 7% of the gross rice cropped area (Girigan and Manjula, 2018) (Fig 1). The replacement of traditional rice varieties from farmers' fields indicates the loss of valuable plant genetic resources for future food and nutritional security.

Apart from the dietary needs, ethnic communities and farm families in Kerala use TRVs for nutraceutical and healthcare purposes (Girigan and Manjula, 2018). Traditional

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healthcare practitioners suggest TRV such as '*Njavara*' for the treatment of arthritis and rheumatism and for whole-body massage. Foods prepared from different mixtures of medicinal herbs and traditional rice varieties are suggested for curing many diseases and increasing immunity. Similarly, rice is an integral part of many life cycle rituals and the harvest of rice is celebrated as a festival across southern India. This indicates the importance of TRV as food, medicine, culture and spirituality. Hence Conservation of these genetic resources is vital for protecting traditional knowledge, ensuring food security and nutritional well-being. This article analyses three interlinked aspects of TRVs by exploring the nutritional advantages of these rice varieties for addressing malnutrition through the consideration of ethnic knowledge and practices related to the use of rice in nutraceutical and through the undertaking of nutritional analysis of selected traditional varieties extensively cultivated in the Wayanad district.

MATERIALS AND METHODS

The nutritional analysis of the varieties was conducted in CFTRI, Mysore in the year 2022. Forty five traditional rice cultivating farmers from Wayanad district of Kerala, India was selected randomly for focussed group discussion followed by personal interviews.

Nutritional advantages, Ethnic knowledge of traditional rice varieties

Focus group discussions and key informant interviews were conducted among forty five traditional rice cultivating farmers of tribal communities such as the Kurichiyas and the Kurumas to elicit, nutritional advantage, ethnic knowledge and practices related to the use of rice as a nutraceutical. Three focus group discussions with 15 farmers each followed by personal interviews to document the traditional wisdom associated with the use of rice for maintaining health and wellness.

Analysis of nutritional contents

Eight traditional varieties, namely, *Adukkan, Veliyan, Chenellu, Chenthadi, Chomala, Thondi, Mullankaima* and *Kalladiaryan,* which are preferred and mostly cultivated, were selected for nutritional analysis.

The samples of traditional rice varieties for analysis were collected from the farmers' fields through participatory panicle selection to ensure that there was no varietal admixture and were dried to appropriate moisture content. The proximity of *Adukkan, Veliyan* and *Thondi,Chenellu, Chomala, Chenthadi* and *Mullankaima* was analysed using the test method followed by AOAC 20th Ed. 2016, 953.07,923.03, 999.36,984.13 and 962.09 and carbohydrate levels were estimated using the method of Gopalan, 1996. The analysis of minerals in the selected varieties was performed using atomic absorption spectrophotometric method described in AOAC 20th Ed.201 985.35.

RESULTS AND DISCUSSION

The nutritional advantage of traditional

The nutrient content in rice depends on numerous factors, such as the variety, soil nutrients, degree of milling and the method of cooking dishes for consumption (Priya *et al*., 2019). Studies have shown that traditional rice varieties (TRVs) exhibit superior nutritive value higher in minerals, vitamins and dietary fibre and lower in sugar compared with modern rice varieties (MRVs). This scientific evidence complements farmers' observations that TRVs provide greater energy and nutritional satisfaction, particularly in labour-intensive settings. Currently, the rice available in the market comes in polished form. During the process of polishing, significant proportions of vitamins, minerals and valuable antioxidant compounds are lost - for example, the bran layer removed by milling contains most of the fibre, minerals and bioactive compounds (Baruah *et al*., 2025). The shift from traditional hand-pounded rice to milled rice was even criticized by Mahatma Gandhi in 1940, as they removed the protein coat/bran which consist pericarp, aleurone, a subaleurone layer and germ, that contains large amounts of nutrients and bioactive compounds, thereby reducing it's the nutritional value (Rao and Swaminathan, 2017; Kaur *et al*., 2016).

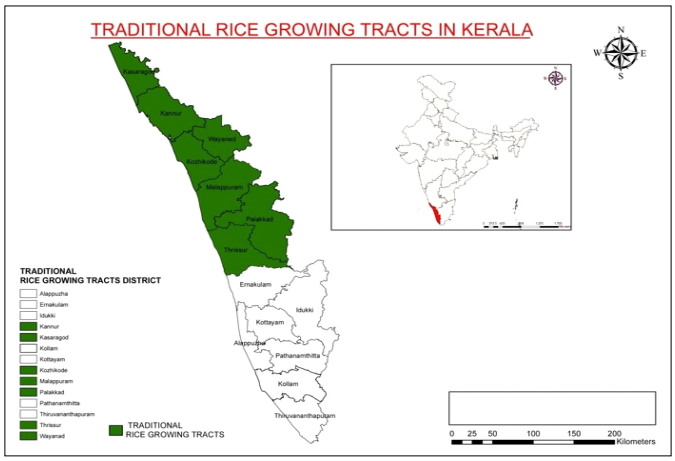


Fig 1: Traditional rice growing tracts of Kerala.

The most commonly cultivated TRVs include *Adukkan, Veliyan, Chenellu, Chenthadi, Chomala, Thondi, Gandakasala, Jeerakasala, Mullankaima and Kalladiaryan* and they also have the ability to overcome various biotic and abiotic stresses. Among these varieties, *Chomala* is a white rice variety and *Gandaksala, Jeerakasala and Mullankaima* are aromatic rice varieties. TRVs have been shown to contain higher levels of key nutrients and dietary fibre compared with many MRVs, which helps explain farmers' observations that TRVs supply substantial energy and nutrition (Krishnankutty *et al*., 2025).

Ethnic knowledge and practices related to the use of rice as a nutraceutical

Rice is consumed in different forms in combination with leafy greens, tubers, fish, meat, pulses, fruits, *etc.* For low income families, rice is the major source of nutrition and energy. Traditional wisdom and long years of experiences make them choose the best varieties that that promotes health, prevents disease and further give them nutrition and energy to undertake physical hard works. For example, the farmers in Wayanad prefer to consume a variety called '*Veliyan*', which they believe that the consumption of this rice gives them a feeling of satiety and provide energy to carry out hard work physically (Girigan and Manjula, 2018).

Traditional rice varieties also vary in their taste, colour, size and aroma, which make them suitable for preparing different dishes. In order to satisfy diet requirement in different occasions, farmers cultivate diverse varieties of rice. For instance, for preparing breakfast items, farmers in Wayanad prefer rice varieties like *Kaima*, *Uruni Kaima* and *Thonnuran Thondi etc*. with white kernel; for lunch they prefer rice with red kernel like *Chettu Veliyan, Mara Thondi, Chenthadi* and *Chomala*. Varieties like *Pal Veliyan* and *Pal Thondi* are preferred for preparing rice gruel. Aromatic rice varieties like *Gandhakasala* and *Jeerakasala* are preferred to be served to distinguished guests.

People prepare different dishes at different occasions using rice. 'Rice milk' is a special dish popular among the *Paniya* tribes in Wayanad. They collect pre-mature grains during the milky stages and squeeze the milk out. The collected milk is kept overnight and allows the milk turns from liquid state to solid state. Either with or without salt or sugar they consume the solid rice milk, which they say provides more energy and freshness. Similarly, *Pazhamkanji* dishes are another popular form of dish prepared across Kerala. The cooked rice was soaked overnight in water to make *Pazhamkanji*. This rice is eaten the following morning. *Pazhamkanji is* supposed to cool and thus be an ideal morning beverage during the summer months. Its nutritional enrichment may be due to slight fermentation. Rice gruel always acts as an oral rehydration salt (ORS) when people are infected by fever or diarrhoea. Red rice gruel is an excellent tonic because it is energetic, refreshing, easily digestible and beneficial for health due to its rich bioactive content (Tavhare, 2024).

The culinary importance and nutritional value of traditional rice varieties cultivated in the Wayanad district of Kerala are summarized in Table 1.

Consuming rice as food and medication is a powerful tool for addressing minute health issues at the household level. However, the medicinal use and its healing propertiesrequire further validation to confirm the nutritional effect of these varieties.

Analysis of nutritional content

The results of the proximity analysis obtained for the present study are shown in Table 2.

Moisture content

The moisture content of all the varieties ranged from 7.33 to 12.80% (Table 2). The moisture content was highest for the variety *Chenellu* (12.80%), followed by *Chomala* (12.50%) and *Chenthadi* (7.33%). The shelf life of grains is important in retaining nutritional value and is strongly influenced by the moisture present which also contributes to the taste of prepared rice (Swarnakar, 2019). The acceptable moisture content is 13-14% for extended storage

Table 1: Traditional rice varieties preferred by farmers in Wayanad, Kerala, for consumption.

Variety	Kernel colour	Culinary importance/ Nutraceutical
Veliyan	Red	Tasty, served during fests, fermented porridge provides energy for prolonged physical tasks; brewing liquor.
Thondi	Red	Unique, tasty, Rice gruel good for anaemic persons, rice milk cake prepared, porridge is consumed after postpartum.
Chennellu	Red	Tasty, medicinal, used in cultural occasions, controls diarrhoea and vomiting, regarded as king of rice Good for pregnant women, anaemic persons, rheumatic diseases, stomach diseases, heart problems, cancer.
Chomala	White	Tasty rice gruel, breakfast items are prepared.
Gandhakasala Mullan Kaima Jeerakasala	White	Tasty, aromatic. Used for preparing sweet dishes, breakfasts, biriyani, served for distinguished guests and given to girls reaching puberty.
Chenthadi Adukkan Kalladiyaryan	Red	Tasty, good for noon-meal preparation.

Girigan and Manjula, (2018).

and for preventing insect infestations and microbial growth (Narmilan *et al*., 2021). If the moisture content is high (14-18%), it can be stored for only for 2-3 weeks, as this leads to the development of moulds, loss of viability and reduced eating quality (Abedin *et al*., 2012). The moisture content of all the varieties fell within the acceptable range, which ensured the quality of varieties. A study conducted by Revathy (2018) reported that the moisture content of six modern rice varieties (MRV) in Kerala ranged from 10.5-11.5%.

Total fat

The fat content in the selected rice varieties ranged from 1.20 to 4.90%. The highest fat content was observed for *Kalladiaryan* (4.90%), followed by *Chomala* (4.20%), *Mullankaima* (3.90%) and *Chenellu* (3.90%).

Studies shows that rice with high fat content tend to be tastier and have less starch (Guo *et al*., 2024). A study conducted by Priya *et al*. (2019) reported that various fractions of polished rice and red rice varieties from India have approximately 1% fat. However, in the present study, the total fat content ranged from 1.20 to 4.90%, which might be a reason for the delicious taste of dishes prepared fromTRVs. Revathy (2018) reported that the fat content in HYVs from Kerala varied from 0.24 to 3.50%, which is lower than the result obtained for the present study.

Protein

The protein content in the present study ranged from 4.61to 8.91% (Table 2). The highest protein content was found for *Mullankaima* (8.91%), followed by *Kalladiaryan* (8.7%) and *Adukkan* (7.1%) and the lowest was found for *Chenthadi* (4.61%). The protein content in HYV from Kerala was found to vary from 4.70 to 5.50% (Revathy, 2018) which indicates that the protein content is greater in TRV than in HYV cultivated in Kerala. It is estimated that rice provides 24.1% of the required dietary protein (Kennedy *et al*., 2003) which is easily digestible protein (>90% digestibility) compared to wheat protein. TRVs such as *Mullankaima* and *Kalladiaryan* are better sources of protein than the MRVs commonly consumed in Kerala.

Crude fibre

Table 2 shows the crude fibre content of the TRVs. The highest fibre content was reported for *Kalladiaryan* rice (0.90%) and the lowest was reported for *Chenellu*, *Chenthadi* and *Mullankaima* (0.30%). The fibre content in the rice varieties commonly used in Kerala ranges from 0.18to 0.47% (Revathy, 2018). In the present study, the fibre content ranged from 0.3 to 0.9%, which was greater than that of HYV in Kerala. A daily intake of at least 25g of fibre is recommended to reduce the risk of chronic diseases such as type II diabetes, which is a major problem in developing countries (Alahmari *et al.,* 2024). Dietary fibre hinders the action of hydrolytic enzymes in the small intestine reducing the absorption of carbohydrates,whichreduces type 2 diabetes (Jenkins, 1978).

Carbohydrates

The carbohydrate content was greater than 70.00% in all the varieties except for *Chenellu* (62.32%) and *Chenthadi* (68.92%). Table 2 clearly shows that the highest carbohydrate content was found in *Mullankaima* (88.30%), followed by *Veliyan* (84.32%). Priya *et al.* (2019) reported carbohydrate contents of 71.31 and 84.75% in pounded rice, which was in agreement with the present study. Rice carbohydrate levels are related to the glycemic index (GI), which is an important indicator for individuals who are conscious of controlling the glycemic index (Li *et al*., 2024). In rice, carbohydrates exist in the form of starch and polishing leads to increased carbohydrate (Farooq and Yu, 2022).

Minerals

Minerals are essential nutrients for effective functioning of the body (Wang *et al*., 2011) and consuming rice can provide an appreciable amount of minerals (Huang *et al*., 2016). However, in milled and polished rice, the availability of minerals is low, as it is present mainly in the bran (Shylaraj, 2018). In the present study, the mineral compounds in the rice varieties were found to be in the order K > Ca > Zn > Fe. This finding is in accordance with the study reported by Saleh *et al.* (2019) on Thai Jasmine brown rice.

The calcium content in the TRV under study ranged from 16.15 to 85.63 mg 100 gm^{-1}. The highest concentration was found for *Thondi* (85.63 mg), followed by *Adukkan* (55.40 mg). The available calcium in HYV from Kerala was

Table 2: Proximate and mineral composition of selected traditional rice varieties.

Varieties	Moisture %/wt	Total fat%/wt	Protein %/wt	Crude fibre%	Carbohydrates%	Calcium mg/100 gm	Iron mg /100 gm	Zinc mg/ 100 gm	Potassium mg/100 gm
Adukkan	11.40	1.20	7.10	0.70	78.20	55.40	2.81	2.90	221.87
Kalladiaryan	12.40	4.90	8.70	0.90	71.90	46.60	1.54	2.16	164.84
Thondi	11.90	1.50	6.50	0.50	78.40	85.63	5.66	2.11	189.12
Chennellu	12.80	3.90	4.70	0.30	62.32	28.55	2.31	2.27	212.77
Chomala	12.50	4.20	5.00	0.50	73.20	25.24	1.62	2.13	176.74
Chenthadi	7.33	1.50	4.61	0.30	68.92	31.40	1.95	2.19	218.30
Mullankaima	9.70	3.90	8.91	0.30	88.30	16.15	2.04	2.18	203.21
Veliyan	8.90	2.20	5.10	0.50	84.32	45.43	3.19	2.97	240.77
S.E [±m]	0.58	0.58	2.52	0.12	1.15	2.31	0.76	-	5.77
C.D [0.05]	1.73	1.73	0.84	0.35	3.46	6.92	2.29	NS	17.31

found to vary from 4.90 to 6.76 mg 100 gm^{-1} (Revathy, 2018), which is compared to TRVsstudied.

The iron content among the varieties ranged from 1.54 to 5.66 mg 100 gm^{-1} of which the highest was found for *Thondi* (5.66 mg 100 gm^{-1}), followed by *Veliyan* (3. 19 mg 100 gm^{-1}) and the lowest concentration was found for *Kalladiaryan* (1.54 mg 100 gm^{-1}). Studies on MRVin Kerala have reported iron contents ranging from 0.39 to 0.61 mg 100 gm^{-1} (Revathy, 2018). These results indicate that, compared to HYV, TRV are good sources of iron. Iron deficiency, a major public health concern in rice-growing regions, is a principal cause of anaemia that can lead to maternal mortality during childbirth, reduced work performance and impaired immune competence in adults (Zhang *et al*., 2024). This issue can be partially addressed by promoting the consumption of traditional rice varieties, particularly in populations that cannot afford or access diverse foods.

The variations in zinc content among the TRV (2.11-2.97 mg 100 gm^{-1}) were negligible, but the zinc content was found to be greater than that in modern varieties (1.07 to 1.32 mg 100 gm^{-1}). Iron and zinc are two of the most important micronutrients for the human body (Verma and Srivasta, 2017). Iron is an indispensable component of the blood protein haemoglobin and influences the function of regulating hormones and homeostatic conditions in the body. These findings are in line with those of a study conducted Tripathy *et al*. (2021) who reported that high-yielding rice varieties are poor sources of essential micronutrients such as iron and zinc.

The potassium content in the present study ranged from 164.84 mg - 240.77 mg 100 gm^{-1}. The highest potassium content was reported for Veliyan variety (240.77 mg), followed Adukkan variety (221.87 mg). A study reported that the potassium content in red rice varieties ranged from 118.33-127.63 mg 100 gm^{-1} (Robita, 2013). Hypertension is a major public health concern in the majority of third-world countries and potassium plays an important role in controlling blood pressure in the human body (National Research Council, 1989). Compared with all other varieties, traditional rice varieties are reliable sources of potassium.

Malnutrition and chronic diseases are among the major problems that affect the achievement of sustainable development goals in developing nations such as India, where rice is the prime source of nutrition (Dipti *et al*., 2012). Iron deficiency is responsible for approximately half of all anaemia cases globally (Loy *et al*., 2019). Iron deficiency causing anaemia is widespread among rice-consuming countries, possibly due to the consumption of polished rice, which has low iron content. Similarly, in zinc deficiency, the problem can be attributed to the consumption of polished rice. Zinc deficiency can lead to problems with neuropsychological function, increasing acute and chronic diarrhoea in children and leading to mortality, retarded foetal growth and foetal abnormalities (Ahmad *et al.,* 2023). A change in dietary pattern with dietary diversity (Black *et al*., 2008) can help to minimize problems related to hidden hunger, which is a result of mineral or vitamin deficiency. However, for most of the rural poor, who cannot afford dietary diversity, promoting the consumption of traditional rice varieties is a way out from malnutrition and hidden hunger.

The present study clearly showed that, compared with MRV,TRV are nutritionally rich. Among the varieties studied, the variety *Kalladiaryan* had the highest amount of total fat (4.90%/wt) and crude fibre (0.90%/wt). The protein (8.91%/wt) and carbohydrate (88.30%/wt) contents were found to be the highest for *Mullankaima* variety. *Thondi* was analysed with highest calcium (85.63 mg 100 gm^{-1}) and iron (5.66 mg 100 gm^{-1}) whereas *Veliyan* variety had the highest zinc (2.97 mg 100 gm^{-1}) and potassium 240.77 mg 100 gm^{-1}. The results of the present study showed that each variety is unique on its contribution to nutrition. The nutritional value of rice, especially the micronutrient levels, varies from variety to variety; hence,TRVs perform better than MRVs. Since rice is the staple food of the rural poor, efforts to make staple foods more nutritive are effective at reducing malnutrition in the country. The effective utilization of nutritionally rich traditional rice varieties in the breeding process may elevate micronutrient levels in most consumed rice. Utilizing TRV for fortification and consumption of unpolished rice could help to address nutritional-related public health problems among different age groups.

CONCLUSION

The present study demonstrates that the traditional rice varieties (TRVs) possess remarkable nutritional and genetic value. The differences in nutrient composition among the varieties indicate that the nutritional richness is not uniform across all the TRVs. Varieties like Mullankaima and Kalladiaryan exhibited higher protein, fat and fibre contents, while Thondi, Veliyan and Adukkan contained greater levels of calcium, iron, zinc and potassium. These varieties is a combination of nutritional superiority and adaptability to local agro-ecological conditions, making them suitable for sustainable cultivation.

This nutritional diversity elevates the functional and dietary potential of traditional rice varieties as natural nutraceutical that can help in addressing malnutrition and micronutrient deficiencies in rural communities. Encouraging the cultivation and consumption of such nutrient-dense varieties through on-farm conservation, farmer-led varietal selection and their inclusion in public food and nutrition programs would strengthen both nutritional security and biodiversity conservation. Promoting these traditional landraces thus offers a practical, low-cost and ecologically sound pathway toward improved health and resilience of local food systems.

Conflict of interest

The authors declare that there are no conflicts of interest regarding the publication of this article. No funding or sponsorship influenced the design of the study, data collection, analysis, decision to publish, or preparation of the manuscript.

REFERENCES

Abedin, M., Rahman, M., Mia, M. and Rahman, K. (2012). In-store losses of rice and ways of reducing such losses at farmers' level: An assessment in selected regions of Bangladesh. *Journal of Bangladesh Agricultural University*. **10:** 133-144.

Ahmad, J., Nasir, S. and Kumar, A. (2023). Zinc deficiency and its impact on human health: A review. *Frontiers in Nutrition*. **10:** 1210563. https://doi.org/10.3389/fnut.2023.1210563.

Alahmari, L.A. (2024). Dietary fiber influence on overall health, with an emphasis on CVD, diabetes, obesity, colon cancer and inflammation. *Frontiers in Nutrition*. **11:** 1510564. https://doi.org/10.3389/fnut.2024.1510564.

Baruah, D., Das, P., Nath, T., Neog, B. and Barooah, M.J. (2025). Processing raw rice bran to potential functional food for human consumption. *Asian Journal of Dairy and Food Research*. doi: 10.18805/ajdfr.DR-2233.

Black, R.E., Allen, L.H., Bhutta, Z.A., Caulfield, L.E., Mercedes de, O., Ezzati, M., Mathers, C. and Rivera, J. (2008). Maternal and child under nutrition: Global and regional exposures and health consequences. *Lancet*. **371:** 243-260.

Dipti, S.S., Bergman, C., Indrasari, S.D., Herath, T., Hall, R., Lee, H., Habibi, F., Bassinello, P.Z., Graterol, E., Ferraz, J.P. and Fitzgerald, M. (2012). The potential of rice to offer solutions culture.gov.in/content/uploads/2023/04/AGRICULTURAL-STATISTICS-2023.pdf.

Farooq, M.A. and Yu, J. (2022). Starches in rice: Effects of rice variety and processing. *Foods*. **14(12):** 4013.

Girigan, G. and Manjula, M. (2018). Specialty rice biodiversity of Kerala: Need for incentivizing conservation in the era of changing climate. *Current Science*. **114(5):** 997-1006. doi: 10.18520/cs/v114/i05/997-1006

Gopalan, C. (1996). Nutritive Value of Indian Foods. National Institute of Nutrition, ICMR, Hyderabad.

Government of Kerala [GoK]. (2023). Kerala Economic Review. State Planning Board, Thiruvananthapuram. https://keralaagriculture.gov.in/ content/uploads/2023/04/ AGRICULTURAL-STATISTICS-2023.pdf

Guo, J., Zhou, X., Chen, D., Chen, K. and Ye, C. (2024). Effect of fat content on rice taste quality through transcriptome analysis. *Genes*. **15(1):** 81.

Huang, Y., Tong, C., Xu, F., Chen, Y., Zhang, C. and Bao, J. (2016). Variation in mineral elements in grains of 20 brown rice accessions in two environments. *Food Chemistry*. **192:** 873-878.

Jenkins, D.J., Wolever, T.M., Leeds, A.R., Gassull, M.A., Haisman, P., Dilawari, J., Goff, D.V., Metz, G.L. and Alberti, K.G. (1978). Dietary fibres, fibre analogues and glucose tolerance: Importance of viscosity. *British Medical Journal*. **1:** 1392-1394.

Kaur, B., Ranawana, V. and Henry, J. (2016). The glycemic index of rice and rice products: A review and table of GI values. *Critical Reviews in Food Science and Nutrition*. **56(2):** 215-236.

Kennedy, G., Burlingame, B. and Nguyen, V.N. (2003). Nutritional Contribution of Rice and Impact of Biotechnology and Biodiversity in Rice-consuming countries. In: Proceedings of the 20th Session of the International Rice Commission, 23-26 July 2002, Bangkok, Thailand. FAO, Rome, pp. 59-70.

Krishnankutty, J., Sasidharan, L.P., Raju, R.K., Kaladharan, N., Purath, A.U., Sugathan, V., Blakeney, M. and Siddique, K.H.M. (2025). Traditional rice varieties, consumer segmentation and preferences: A case study from Kerala, India. *Sustainability*. **17(12):** 5467

Li, J., Yoshimura, K., Sasaki, M. and Maruyama, K. (2024). The consumption of high-amylose rice and its effect on postprandial blood glucose levels: A literature review. *Nutrients*. **16(23):** 4013.

Loy, S.L., Lim, L.M., Chan, S-Y., Tan, P.T., Chee, Y.L., Quah, P.L. and Chong, Y.S. (2019). Iron status and risk factors of iron deficiency among pregnant women in Singapore: A cross-sectional study. *BMC Public Health*. **19:** 397.

Manilal, K.S. (1991). Ethnobotany of the rices of Malabar. In: Contribution to Indian Ethnobotany. Botanical Survey of India, Calcutta: Scientific Publishers.

Narmilan, A., Niroash, G., Mowjood, M.I.M. and Akram, A.T. A. (2021). Effect of pads and thickness of paddy on moisture removal under sun drying. *Agricultural Science Digest*. **41(4):** 572-577. doi: 10.18805/ag.D-327.

National Research Council. (1989). Recommended dietary allowances. National Academy Press, Washington.

Priya, T.S.R., Nelson, A.R.L.E., Ravichandran, K. and Antony, U. (2019). Nutritional and functional properties of coloured rice varieties of South India: A review. *Journal of Ethnic Foods*. **6:** 11.

Rao, N. and Swaminathan, M.S. (2017). A farmer-led approach to achieving a malnutrition-free India. *Agricultural Research*. **1:** 1-7. doi:10.1007/s40003-016-0240-8.

Revathy, G.N. (2018). Quality evaluation of KAU red rice (*Oryza sativa* L.) varieties. M.Sc Thesis, Kerala Agricultural University, Thrissur, 82p.

Robita, R. (2013). Quality Analysis of Oganic Rice. M.Sc Thesis, Kerala Agricultural University, Thrissur, 149p.

Saleh, A.S.M., Wang, P., Wang, N., Yang, L. and Xiao, Z. (2019). Brown rice versus white rice: Nutritional quality, potential health benefits, development of food products and preservation technologies. *Comprehensive Reviews in Food Science and Food Safety*. **18:** 1070-1096.

Shylaraj, K.S., Soumya, G.N. and Shimi, K.C. (2018). Comparative analysis of grain quality and nutraceutical properties of selected rice varieties from Kerala. *Current Science*. **114(5):** 1088-1094.

Swarnakar, A.K. (2019). Shelf life estimation of preconditioned brown or unpolished rice (*Oryza sativa*) and its effect in microwave puffing. *Asian Journal of Dairy and Food Research*. **38(3):** 231-236. doi: 10.18805/ajdfr.DR-1475.

Tavhare, S.D. (2024). Dietary therapeutics of rice and Ayurveda: A bird's eye view. *Journal of Dietetics and Research in Ayurveda*. **5(1):** 23-30.

Tripathy, S.K. (2021). Phenotyping and association analysis of grain zinc and iron content with seed yield in diverse local germplasm of rice. *Indian Journal of Agricultural Research*. **58(6):** 1152-1157. doi: 10.18805/IJARe.A-5843.

Verma, D.K. and Srivasta, P.P. (2017). Proximate composition, mineral content and fatty acids analyses of aromatic and non-aromatic Indian rice. *Rice Science*. **24(1):** 21-31.

Wang, K.M., Wu, J.G., Li, G., Zhang, D.P., Yang, Z.W. and Shi, C.H. (2011). Distribution of phytic acid and mineral elements in three indica rice (*Oryza sativa* L.) cultivars. *Journal of Cereal Science*. **54(1):** 116-121.

Zhang, L., Chen, S., Xie, X. and Hou, P. (2024). The global burden of maternal disorders attributable to iron deficiency: An analysis for the Global Burden of Disease Study. *BMC Public Health*. **24:** 1148.