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Review Article

Narrative Review on Nutritional Composition, Antioxidant Activity and Health Benefits of Sri Lankan Traditional Rice Varieties

Ratnayake W.M.K.M.[1*] and Karunarathna K.A.A.U.[2]
[1]*Department of Cosmetic Science, Faculty of Health Sciences, CINEC Campus, Malabe, Sri Lanka.*
[2]*Department of Basic Sciences, Faculty of Allied Health Sciences, University of Sri Jayewardenepura, Gangodawila, Nugegoda, Sri Lanka.*

Abstract
Rice is a staple food in most developing countries, including Sri Lanka. Rice belongs to the genus Oryza and the varieties of rice passed down from preceding generations are known as 'traditional', 'inheritance' or 'indigenous' rice varieties. There are various traditional rice varieties of Sri Lanka namely "Suwadal", "Nilkanda", "Kalu heeneti", "Sudu heenati" "Ma wee", "Pachchaperumal", "Kurulu thuda", "Rath el", "Madathawalu, "Sudu murunga", "Pokkali", "Gurusinghe wee", "Kahawanu", "Nilkanda", "Unakola samba" and "Hetadha wee". According to the Sri Lankan ethnomedicine and folklore, some of these are claimed to have medicinal properties.

Keywords: Traditional rice, *Heenati, Kahawanu, Pachchaperumal, Kurulu thuda*

Introduction

Rice is one of the globally cultivated cereal grains and, it belongs to the genus *Oryza*. It is the world's second-largest produced cereal after maize [1]. There are more than 40,000 varieties of rice and, *Oryza sativa* Linn. is the main cultivating rice species [2, 3]. Rice is the staple food in most Asian countries, including Sri Lanka [1, 4, 5]. The average per capita rice consumption in Sri Lanka is 92 kg/year or 250 g/day. It is consumed by every household in each segment of the population [6].

Rice cultivation has a long and parallel relationship with its history and culture, and Sri Lankans have practiced an agriculture-based lifestyle for the past three millennia. According to the evidence collected through written history and archaeology, rice cultivation of the island goes back to 900-600 BC. The irrigation tanks and canals in the dry zone provide historical evidence that rice farming has been one of the island's major occupations over the past two millennia. During the days of the ancient Sinhalese kings, hundreds of rice or paddy varieties were cultivated as a major dietary source [4, 7]. The varieties of rice passed down from preceding generations are known as 'traditional', 'inheritance' or 'indigenous' rice varieties. These rice varieties have been conserved, developed and used by Sri Lankan farmers for over 3000 years. These varieties include beneficial characteristics that helped them survive from climate change impacts such as droughts, heavy rains, and floods, compared to newer varieties used in chemical-intensive paddy cultivations [8].

According to the Sri Lankan ethnomedicine and folklore, some of these are claimed to have medicinal properties [9, 10]. In the past, these

*Corresponding author: kalpani.ratnayake@cinec.edu
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traditional varieties of rice were widely used for the preparation of healthy dishes such as “lunu kenda” (a type of rice gruel) and “kola kenda” (gruel made with rice and herbs or leafy greens). Further, Sri Lankan folk medicinal practitioners have used many of these traditional rice varieties such as Kalu heenati, Sudu heenati, Maa wee for the preparation of herbal medicines.

However, the traditional or heirloom varieties of rice that were cultivated have been widely replaced with new and improved varieties of rice. This is mainly because rice farmers can obtain a higher yield from these varieties of rice spending the same time taken to seed, grow and harvest the traditional varieties. Even though they do not produce a high yield, these traditional rice varieties have more nutrients and health benefits compared with the new improved varieties. Therefore, much attention has been gained among policymakers, farmers, food scientists, nutritionists, and other health professionals in the country to cultivate and promote these traditional varieties. Hence, currently, they have good demand and high market value.

There are various traditional rice varieties in Sri Lanka namely “Suwadal”, “Nilkanda”, “Kalu heeneti”, “Sudu heenati” “Ma wee”, “Pachchaperumal”, “Kurulu thuda”, “Rath el”, “Madathawalu, “Sudu murunga”, “Pokkali”, “Gurusinghe wee”, “Kahawanu”, “Nilkanda”, “Unakola samba” and “Hetadha wee”. Most of these traditional rice varieties are red rice varieties. Pachchaperumal, Kalu heenati, Kuruluthuda, Marathawalu, and Ma wee are some of the important red rice varieties, and Suwadal, Sudu heenati, Rath el, Murungakayan are examples of white rice varieties.

Therefore, the aim was to review nutritional composition, antioxidant activity, and health benefits of Sri Lankan traditional rice varieties; ‘indigenous’ rice varieties. This review includes the various traditional rice varieties of Sri Lanka namely “Kalu heeneti”, “Sudu heenati”, “Kurulu thuda”, “Madathawalu”, “Masuran”, “Suwadel”, “Ma wee”, “Pachchaperumal”, “Rath el”, “Gonabaru”, “Pokkali” and “Sudu Murunga”.

Methods

A narrative review was conducted with articles searched through web searching engines, Google Scholar, PubMed, and Scopus using the keywords, “Nutrition”, “Sri Lankan”, “Traditional” and “Rice”. Twenty-nine articles which were published in the period 1999 to 2023, were found on traditional rice varieties in Sri Lanka.

Results

Kalu heenati

Kalu heenati is one of the popular traditional rice varieties in Sri Lanka. It is a highly nutritious red rice that is suitable for daily consumption. It is literally translated as “dark, fine grain” and it is named because of the colour of its lemma and palea, which turns blackish at maturity. According to previous studies, the composition of Kalu heenati has shown protein (9.1-11.4%), fat (2.7%), crude fiber (1.6%), ash (1.9%), carbohydrates (69.6-71.9%), iron (2.7±0.2%%) and zinc (3.5±0.2%%) [11].

Although the palatability of cooked rice is rather low, it is recommended for daily consumption and lactating mothers due to its high nutritional value. Also, it is believed that this traditional rice variety is beneficial in enhancing sexual potency and physical strength, controlling diabetes, regulating bowel movement, diarrhoea, and lower cholesterol. The porridge made with Kalu heenati rice is recommended for hepatitis patients. Further, the gruel of Kalu heenati can control toxic effects of snake bites [8].

In 2008, Zawistowski and his co-workers had experimented to evaluate the efficacy of an anthocyanin pigment rice (e.g. black rice) to

mitigate the onset of hypercholesterolemia in Wistar Kyoto rats fed atherogenic diets. They found that the black rice extract had ability to decrease the total cholesterol level [12]. Based on this scientific evidence, Kalu heenati also reduces cholesterol levels in blood as they have blackish colouration at the maturity stage. This justifies the use of Kalu heenati as a source to lowering cholesterol, in folk medicine.

Furthermore, black rice is rich in dietary fibers [13]. Hence, the fact that Kalu heenati variety may also be a good source of dietary fiber supports the use of Kalu heenati to regulate bowel movements and constipation [14].

According to Prasantha (2018), Kalu heenati contains 72.1±0.3% carbohydrates and 27.2±0.1% amylose. They determined the *in-vivo* glycemic index (64.0±2.5) and identified Kalu heenati as a medium glycemic index rice cultivar [15]. Also, Kariyawasam and co-workers have shown that Kalu heenati contains the highest free radical scavenging activity in DPPH assay compared to other traditional rice varieties tested in their experiment (Pokkali, Kahawanu, Sudu murunga) [16].

Sudu heenati

Sudu heenati is also one of the popular traditional rice varieties in Sri Lanka. Even though the name implies white rice, this variety produces red bold grains. This variety can be cultivated in all areas of Sri Lanka and grows well even during the monsoon season. Sudu heenati is considered to have the highest nutritional and medicinal value amongst all [17]. This variety of rice is rich in vitamin E, iron, zinc and other natural antioxidants. It is said that Sudu heenati is suitable for treating inflammation, diabetes, cancer, neurological diseases, and cholesterol [18]. When cooked, these grains have a slightly sticky consistency and consumption of cooked rice is a remedy for constipation [19]. This variety also helps to improve the human immune system. According to previous studies, the composition of Sudu heenati has shown a composition of proteins (12.08±0.03%), fats (2.63±0.17%), ash (1.60±0.05%), total carbohydrates (83.69±0.17%), and dietary fibers (5.15±0.07%) [20].

Studies have shown that Sudu heenati has a low starch digestion rate (53.44±0.53), indicating that this may be a low glycemic index rice. This property confirms the importance of Sudu heenati varieties in the management of diabetes and its complication [20]. In 2017, Abeysekera and co-workers found that rice bran of Sudu heenati has moderate nitric oxide scavenging activity (IC_{50} = 53.89±6.48 µg/ mL) compared to the reference standard rutin which was 17.62±0.01 µg/ mL [21]. Nitric oxide is one of the main reactive chemical mediators that can be implicated in certain chronic diseases' pathogenesis. Hence, nitric oxide inhibition activities of Sudu heenati bran plays a vital role in the prevention of various chronic diseases.

Kuruluthuda

Kuruluthuda is a variety of traditional red rice with medium-sized grains, and the name came from a word meaning 'bird's beak'. It has a unique, pleasant taste. Samaranayake and his co-workers have shown that Kuruluthuda variety contains 13.65±0.12% of moisture, 8.44±0.13% of crude protein, 1.50±0.04% of crude ash, 3.14±0.06% of crude fat, 4.88±0.06% of total dietary fiber, 82.04±0.16% available carbohydrates, and 2.92±0.15% of sugar in dry basis [22]. Further, it is rich in fatty acids. In the bran oil of Kuruluthuda, there are 23.50±0.75% of palmitic acid, 49.48±0.58% of oleic acid, and 22.16±0.89% linoleic acid [22].

According to Samaranayake *et al.* (2017), the Kuruluthuda variety has shown antioxidant activity on ferric reducing antioxidant power (FRAP) assay and ABTS radical scavenging assay,

which was 6.79±0.42 mmol $FeSO_4$/100 g of bran in FRAP assay and 13.13±0.28 mmol Trolox/100 g of bran in ABTS assay. Hence, consumption of Kuruluthuda with the bran is important in obtaining rice bran based natural antioxidants and, therefore possibly important in the dietary management of oxidative stress associated chronic diseases [22].

Madathawalu

Madathawalu is another type of red rice that has traditionally been cultivated in Sri Lanka. The protein and mineral content of these grains is comparatively higher than most other heirloom varieties of rice [23, 24]. Studies have shown that the Madathawalu variety contains 12.33±0.02% of moisture, 11.52±0.07% of crude protein, 1.5±0.2% of crude ash, 2.97±0.03% of crude fat, and 84.01±0.3% of total carbohydrates in dry basis [21].

In 2017, Hemanthi and her co-workers [25] showed that organically grown Madathawalu seed samples has high antioxidant activity on DPPH assay (16.89±0.78 mg ascorbic acid equivalent/ g of rice extract) to respective non-organically produced seed samples (9.40±0.25 mg ascorbic acid equivalent/g of rice extract). Further, they found that organically grown Madathawalu has a high total phenolic content (2.22±0.03 mg gallic acid equivalent/g of rice extract) also compared to the non-organically produced sample (1.42±0.01 mg ascorbic acid equivalent/g of rice extract). The red pericarp rice varieties used in their study (Madathawalu and Handiran) showed higher antioxidant values than the tested white pericarp variety which is Suwandel [25].

The scientific data on the anti-bacterial activity of rice varieties also helps to assess the health benefits of traditional varieties since rice has emerged as an intriguing source of natural antibacterial agent [26]. According to Hemanthi *et al.* [25], organically grown Madathawalu seed samples have shown zone inhibition in the antimicrobial susceptibility test, which were done for *Salmonella typhi* (3.4±0.3) and *Staphylococcus aureus* (5.34±0.3). However, these values were significantly higher for non-organically produced Madathawalu seeds which showed 3.83±0.3 for *Salmonella typhi* and 5.73±0.2 for *Staphylococcus aureus*. However, both organically and non-organically produced Madathawalu seed samples had not shown an anti-microbial effect on *Escherichia coli* [25].

According to Prasantha (2018), Madathawalu were categorized under traditional rice cultivar with high amylose as it contains 27.2±0.1 g of amylose/100 g of dry weight. Also, Madathawalu showed 64.0±0.25 of glycemic index which was categorized as medium glycemic index rice [14]. Further, Hemanthi and co-workers (2017) have evaluated the glycemic index of three traditional rice varieties of Sri Lanka, i.e. Madathawalu, Suwandel and Handiran. Among the three test varieties, they found that Madathawalu variety contains the lowest glycemic index. This aided in scientific confirmation of the beneficial effects of Marathahalli in the management of diabetes [15].

Masuran

Studies have shown that Masuran variety contains 10.63±0.63% of protein, 2.71±0.35% of fat, 1.45±0.08% of ash, 85.22±0.73% of total carbohydrates and 4.78±0.11 of dietary fibers on a dry basis. Previous studies showed that the Masuran variety has significantly ($p<0.05$) low rate of *in-vitro* starch digestion rate compared to white bread. It was 53.76±1.19 for Masuran variety whereas 100 for white bread [20].

According to a study conducted by Abeysekera and co-workers [20], the rice bran of Masuran variety significantly reduced the glycemic levels in rats at 15 and 30 min after administration of rice bran extract at 1 g/kg body weight. Hence, Masuran was identified as a Sri Lankan traditional

rice variety with low glycemic index, which can contribute to the management of diabetes and its related complications [20].

Further, Abeysekera and co-workers have found that Masuran variety has significant ($p<0.05$) acetyl cholinesterase inhibitory activity (IC_{50} value = 88.27±6.64), and butyryl cholinesterase inhibitory activity (IC_{50} value = 30.20±1.96) [20]. As dual inhibitory action on both acetyl cholinesterase and butyryl cholinesterase is important in treating Alzheimer's disease and related dementias [27], consumption of the Masuran variety may reduce the risk of having Alzheimer disease. However, brans of Masuran have low inhibitory activity on nitric oxide inhibition (IC_{50} = 569.67±11.96 µg/mL) compared to the reference standard rutin, which was 17.62±0.01 µg/mL [21].

Suwandel

Suwandel is an heirloom rice variety, cultivated organically with traditional rain- fed methods in the southern lowlands of Sri Lanka. As the translated name implies, this is a fragrant white rice with an exquisite aroma. Its milky taste makes Suwandel a common choice for festive occasions and ceremonies [9]. Studies have shown that Suwandel variety contains 13.84±0.07% of moisture, 8.09±0.35% of crude protein, 1.55± 0.01 % of crude ash, 3.28±0.04% of crude fat, 6.28±0.06 % of total dietary fiber, 80.80±0.36% available carbohydrates, 2.28±0.04% of sugar in dry basis [22]. Further, bran oil of Suwandel contains 19.67±0.21% of palmitic acid, 46.66±0.65% of oleic acid and 30.43±0.68% linoleic acid [22]. Also, it contains higher amounts of glutamic acid and higher concentrations of vitamins than other common rice varieties.

The bran of Suwandel has also shown antioxidant activity and it was 2.47±0.17 mmol $FeSO_4$/100 g of bran in FRAP assay and 0.58±0.2 mmol Trolox/100 g of bran in ABTS assay [21]. This antioxidant level is expected to have health promoting effects in reducing the prevalence of non-communicable diseases. Also, it is believed that consumption of Suwandel is particularly good for promoting fair and glowing skin, improve the functioning of the digestive system, help to control diabetes, make aphrodisiac properties, and sweetening the voice by improving vocal clarity and the sharpness [17, 28].

Maa-wee

Ma-wee is a reddish-brown rice variety which has a historical importance in religious ceremonies. There are various sub varieties such as Maa wee, Kuru maa wee (Dwarf variety), Baala maa wee (Short-aged variety), Maha maa wee, Sudu maa wee, Kalu bala maa wee and Palatuwa maa wee. It has a unique texture, and it is best when soaked prior to boiling. It has a nutrient makeup of 13.36±0.04% of moisture, 11.6±0.37% of crude protein, 1.55±0.01% of crude ash, 2.78±0.01% of crude fat, 2.68±0.17% of total dietary fiber, 82.23±0.69% available carbohydrates and 5.86±0.15% of sugar in dry basis [22]. Also, the bran oil of Maa-wee contains 21.83±0.23% of palmitic acid, 42.76±0.75% of oleic acid, and 31.86±0.76% of linoleic acid [22]. This rice variety is also high levels of antioxidants [22].

A rice meal of Maa wee is considered to be a heavy diet which digests slowly. Hence, it has a lower glycemic index (25%-30%) in comparison to other common rice varieties. In Ayurveda, Maa wee is commonly used in orthopedic treatments. The red pericarp is used in the preparations of various indigenous medicines for tissue pains. Also, this variety is recommended for tuberculosis patients as an effective remedy for purging. Further, consumption of meat and Ma wee rice together reduces alcohol intoxication [9].

Pachchaperumal

The word 'Pachchaperumal' means The Lord 'Buddha's colour' and has been considered a

divine rice in the traditional Sinhalese culture. It was often used in alms giving. This is a wholesome red rice variety which when cooked takes on a deep rich burgundy colour. Proximate composition of Pachchaperumal variety has shown that it contains 12.13±0.52% of moisture, 13.27±0.32% of crude protein, 1.70±0.07% of crude ash, 2.75±0.17% of crude fat, and 82.28±0.42% total carbohydrates in a dry basis. As this rice is rich in proteins and other nutrients, it is an excellent choice for your everyday meal. Also, it is believed to be particularly good for children as it is rich in nutrients and proteins. Daily consumption of cooked rice of this variety helps to cool down the body. Moreover, this traditional rice is recommended for diabetes, cardiovascular, and high blood pressure patients [9]. Further, this rice variety is rich in naturally occurring antioxidants [23].

Rathdel

Rathdel is a delicious red rice variety that provides relief to those suffering from cirrhosis [9]. Porridge and soup made with Rathdel can help fight viral fever. It is recommended for skin rashes caused by mental stress and provides relief for ailments in the urinary system. It also helps flush toxic excretory matter and cools the body. Roasted and ground Rathdel raw rice tempered with ghee can be an effective remedy for purging. It is a tested remedy for preventing the formation of stones in the bladder and gall bladder. Porridge made out of Rathdel rice, sarana, sugar, raisins and fresh cow's milk is suitable for those suffering from tuberculosis and lung ailments. Consumption of boiled Rathdel rice mixed with ghee enhances sexual potency [31].

Gonabaru

Gonabaru is a medium-grain red rice variety cultivated in both the dry and wet zones. It is a very rare rice variety that was the staple diet of kings in ancient times. It consists of 8.4% of proteins, 2.2% of fat, 1.0% of crude fiber, 1.5%, of ash, 71-73.5% of carbohydrates, 2.2% of iron and 3% of zinc [26]. It is believed that this variety is a good source for the treatment of diabetes and oxidative stress and consumption with the bran is important in obtaining such valuable nutritional and medicinal properties. It has a medicinal effect on constipation and is very good for the preparation of porridge [31].

Sudumurunga

Sudumurunga is another traditional rice variety with many health benefits. The proximate composition of Sudumurunga variety has shown that it contains 11.9±0.1% of moisture, 9.7±0.3% of crude protein, 1.2±0.0 % of crude ash, 2.7±0.0% of crude fat and 73.6±0.1% total carbohydrates, 1.1±0.0% crude fiber in dry basis [30]. Also, according to the worked done by Kariyawasam and her co-workers [32], this variety consists of 2.1±0.01 mg of Fe, 3.8±0.01 mg of Zn, 0.04±0.0 mg of Mn, 4.52±0.30 mg of K, 1.59±0.20 mg of Mg in 100 g of Sudumurunga rice flour. Hence, all of these nutritious and mineral content may benefit health [32].

Discussion

Sri Lankans started cultivating rice as early as in 800 B.C and rice cultivation was not only considered as an economic activity, but it was the way of life of ancient Sri Lankans. Those rice varieties that were passed down from older generations are called traditional, indigenous rice or heirloom varieties [31].

The Department of Agriculture has identified 150 traditional rice varieties in the 1940s for the cultivation. However, at present, the extension of traditional rice cultivation is very low in Sri Lanka, which is around 0.1% of the total cultivated land area and extends to about 1000 hectare annually [31].

In Sri Lanka there are hundreds of traditional rice varieties which possess nutritional and medicinal

qualities unique to them [8]. It is believed that traditional varieties possess low sugar content, making them the pleasing choice for consumers who are suffering from diabetes, who are overweight, or are keen on regulating their sugar intake. They have a higher amount of glutamic acid, fiber and vitamins. Some people also credit traditional varieties with other health benefits, such as giving sensations of cooling in the body, improving vocal clarity, eyesight, fertility and mitigating rashes [33]. Currently, rice is regarded as a nutraceutical and functional food besides being a staple source of food and a primary source of carbohydrate or starch.

In this present review, we focused on “Kalu hentai”, “Sudu heenati”, “Kuruluthuda”, “Madathawalu”, “Masuran”, “Suwadal”, “Ma wee”, “Pachchaperumal”, “Rathel”, "Gonaburu” and “Sudu murunga”. Of these 11 varieties, eight varieties were red rice, and only three varieties were white [20].

Proximate compositions (moisture, crude protein, crude fat, crude ash, and total carbohydrate) of nutritional properties of the rice grain is always an important fact [21]. Protein is a major nutrient in these rice varieties, and the crude protein level ranged from 8-2%. Carbohydrate and fat levels among these selected varieties ranged from 72-85% and 2-3% respectively. In addition, these rice varieties are rich sources of the most essential micro elements such as iron, Zn and Mn.

Anthocyanins are associated with several health-promoting impacts a, such as anti- oxidative, anti-inflammatory, and anticarcinogenic effects [34]. Coloured rice is also considered a functional food and food ingredient in many Asian countries [35]. The functional properties of anthocyanins in red and black rice varieties have been verified in numerous nutritional cases [36]. Hence, it can be considered that traditional red varieties are more nutritious compared to the traditional white varieties.

The Sri Lankan Government is attempting to re-introduce traditional rice varieties to farmer fields as a component in organic agriculture, mainly due to its nutritive and ayurvedic value and resistance to insects, diseases, and adverse climatic conditions as well as due to the huge human demand for traditional rice.

Conclusion

Although, traditional rice verities show numerous health benefits, only a few varieties had scientifically proven beneficial health effects on diabetes (Kalu heenati, Sudu heenati, Pachchaperumal, Gonabaru), enhancing sexual potency (Kalu heenati and Rathdel), diarrhoea (Kalu heenati, Sudu heenati), constipation (Gonabaru), lowering cholesterol levels (Kalu heenati, Sudu heenati, and Pachchaperumal), snake bites (Kalu heenati), tuberculosis (Maa wee), and alcohol intoxication (Maa wee). Hence, through this review we emphasize that further studies are needed to uncover the health benefits and bioactivities of these valuable traditional rice varieties.

References

1. Abeysiriwardana, D.S. de Z., Dissanayake, D.M.N., Nugaliyadde, L. Rice congress 2000: future of rice in Sri Lanka: second leap forward Gannoruwa proposals. Dept. of Agriculture. 2003;87-97.
2. Biology of Oryza sativa L. (Rice), Department of Biotechnology, Ministry of Science and Technology and Ministry of Environment and Forests, Government of India. 2011; 1- 9.
3. Dogara, A.M. and Jumare, A.I. Origin, Distribution and Heading date in Cultivated Rice, *International Journal of Plant Biology and Research*. 2014;2 (1):1008.
4. Rajapakse, R.M.T., Sandanayake, C.A. and Pathinayake, B.D. Footprints in rice variety

improvement and its impact on rice production in Sri Lanka, Annual Symposium of the Department of Agriculture, Department of Agriculture, Sri Lanka. 2000;2: 423-433.

5. Gunaratne, A., Wu, K., Li, D., Bentota, A., Corke, H. and Cai, Y.Z. Antioxidant activity and nutritional quality of traditional red-grained rice varieties containing proanthocyanidins. *Food Chemistry*. 2013;138: 1153-1161.
6. Herath, H.M.T., Rajapakshe, D., Wimalasena, S., and Weerasooriya, M.K.B. Iron content and availability studies in some Sri Lankan rice varieties. *International Journal of Food Science & Technology*. 2011;46: 1679-1684.
7. Kennedy, G., and Burlingame, B. Analysis of food composition data on rice from a plant genetic resource perspective. *Food Chemistry*. 2003;80: 589-596.
8. Rambukwella, R., and Priyankara, E.A.C. production and Marketing of Traditional Rice Varieties in Selected Districts in Sri Lanka: Present Status and Future Prospects, Hector Kobbekaduwa Agrarian Research and Training Institute. 2016;1: 1- 115
9. Dharmasena, P.B. Traditional rice farming in Sri Lanka, *Economic review*. 2010; 48-53.
10. Abeysekera, W.K.S.M. and Premakumara, G. A.S. Health Food Properties of Traditional Rice in Sri Lanka, Lambert Academic Publishing, Germany. 2016;1-393.
11. SNA Group of Companies, Undated. Traditional Rice. Available at http://www.snagroup.lk/index.php/food-nutrition/traditional-rice/kalu-heenati-detail [Accessed on 10.10.2023]
12. Zawistowski, J., Kopec, A., and Kitts, D.D. Effects of a black rice extract (Oryza sativa L. indica) on cholesterol levels and plasma lipid parameters in Wistar Kyoto rats. *Journal of Functional Foods*. 2009;1: 50 –56.
13. Hu, C., Zawistowski, J., Ling, W., and Kitts, D.D. Black rice (Oryza sativa L. indica) pigmented fraction suppresses both reactive oxygen species and nitric oxide in chemical and biological model system. *Journal of Agricultural and Food Chemistry*. 2003; 51: 5271–5277.
14. Thushara, P.A.N., Godakumbura, P.I. and Prashantha, M.A.B. Importance, health benefits and bioactivities of Sri Lankan traditional rice (*Oryza Sativa* L.) varieties: A review. *International Journal of Agriculture, Environment and Bioresearch*. 2019; 4(3): 119-128.
15. Prasantha, B.D.R. Glycemic index of four traditional red pigmented rice. *Integrative Food Nutrition and Metabolism*. 2018; 5(5): 1-3.
16. Karivawasam, T.L., Godakumbura, P.I., Prashantha, M.A.B., Premakumara, G.A.S., and Abeysekera, W.K.S.M. Antioxidant properties of selected traditional rice varieties in Sri Lanka, Proceedings of the Peradeniya University International Research Sessions, Sri Lanka. 2016; 20: 263.
17. Sri Lanka Export Development Board. Available at https://www.srilankabusiness.com/food-and-beverages/heirloom-rice-from-sri-lanka.html [Accessed on 10.10.2023]
18. Jayadewa C.T., Chiranthika N.N.G., and Gunathilake, K.D.P.P. Comparative studies on nutritional and functional properties of selected traditional rice varieties in Sri Lanka *Tropical Agricultural Research & Extension*. 2023; 26 (2):89-103
19. Li, H., Fitzgerald, M.A., Prakash, S., Nicholson, T.M., and Gilbert, R.G. The molecular structural features controlling stickiness in cooked rice, a major palatability determinant, Scientific reports. 2017;7: 43713
20. Abeysekera, W.K.S.M., Arachchige, S.P.G., Ratnasooriya, Choudhary, M.H., Dalvandi, K. and Chandrasekharan, N.V. Anti-diabetic related health food properties of traditional rice (Oryza sativa L.) in Sri Lanka. *Journal of Coastal Life Medicine*. 2015; 3(10): 815-820.

21. Abeysekera, W.K.S.M., Arachchige, S.P.G., Ratnasooriya, W.D., Chandrasekharan, N.V., and Bentota, A.P. Physicochemical and nutritional properties of twenty-three traditional rice (Oryza sativa L.) varieties of Sri Lanka. *Journal of Coastal Life Medicine*. 2017. 5(8): 343-349.
22. Samaranayake, M.D.W., Yathursan, S., Abeysekera, W.K.S.M., and Herath H.M.T. Nutritional and antioxidant properties of selected traditional rice (*Oryza sativa* l.) varieties of Sri Lanka. *Sri Lankan Journal of Biology*. 2017;2 (2): 25-35.
23. Thushara, P.A.N, Godakumbura, P.I., and Prashantha, M.A.B. Proximate composition and calorie content of selected Sri Lankan traditional rice (*Oryza sativa L.*) based porridges, 12th International Research Conference, General Sir John Kottelawala Defence University:2019; 195.
24. Bhagya K.A.D.L., and Ekanayake S. Physical and nutritional characteristics of less common traditional rice (Oryza sativa L.) varieties of Sri Lanka. *International Journal of Multidisciplinary Studies*. 2020;7 (2): 47-61.
25. Hemanthi, T.L.H.S., Dalukdeniya, D.A.C.K., Rupasinghe, C.P., and Rathnayake, R.M.U.S.K. Antioxidant and antimicrobial activities and starch digestion rate of the organically- and non- organically grown traditional rice varieties in Sri Lanka, *Sri Lanka Journal of Food and Agriculture.* 2017; 3(1): 37-42.
26. Murakami, M., Ota, H., Sugiyama, A., Ishizone, S., Maruta, F., Akita, N., and Tokuyama, T. Suppressive effect of rice extract on Helicobacter pylori infection in a Mongolian gerbil model, *Journal of Gastroenterology*. 2005; 40(5): 459-466.
27. Greig, N. H., Lahiri, D. K., and Sambamurti, K. Butyryl-cholinesterase: an important new target in Alzheimer's disease therapy, *International Psychogeriatrics*. 2002; 4: 77-91.
28. Imam, M.U., Azmi, N.H., Bhanger, M.I., Ismail, N., and Ismail, M. Antidiabetic properties of germinated brown rice: a systematic review. *Evidence Based Complimentary and Alternative Medicine.* 2012:816501
29. Abeysekera, K., Gunasekara, U.K.D.S.S., Premakumara, S. and Abeysekera, K. Antioxidant potential of brans of twenty-nine red and white rice (Oryza sativa L.) varieties of Sri Lanka, *Journal of Costal Life Medicine*. 2017;5 (11); 480-485.
30. Kariyawasam, T.L., Godakumbura, P.I., Prashantha, M.A.B. and Premakumara, G.A.S. Proximate composition, calorie content and heavy metals (As, Cd, Pb) of selected Sri Lankan traditional rice (Oryza sativa L.) varieties, *Procedia Food Science.* 2016; 6: 253 – 256.
31. Ginigaddara, G.A.S., Traditional Rice in Sri Lanka, Rajarata University of Sri Lanka http://agri.rjt.ac.lk/agri_onlinematerials/agricultural_systems/Traditional%20rice%20varieties%20GAS%20Ginigaddara.pdf [Accessed on 10.10.2023]
32. Kariyawasam, T.L., Godakumbura, P.I., Prashantha, M.A.B., and Premakumara, G.A.S. Effect of parboiling on minerals and heavy metals of selected Sri Lankan traditional rice varieties grown under organic farming. *Tropical Agricultural Research & Extension*. 2016;19 (1).
33. Caius, J.F. The medicinal and poisonous plants of India (Reprint), Pbl. Scientific Publishers, Jodhpur, India. 1999.
34. Shipp, J., and Abdel-Aal, E.S. Food applications and physiological effects of anthocyanins as functional food ingredients. *Open Food Science Journal*. 2010; 4: 7-22.
35. Kim, M.K., Kim, H., Koh, K., Kim, H.S., and Lee, Y.S., et al. Identification of anthocyanin pigments in colored rice, *Nutrition and Research Practice*. 2008; 2: 46- 49.
36. Hou, Z., Qing, P., and Ren, G. Effect of anthocyanin- rich extract from black rice (Oryza sativa L. Japonica) on chronically

alcohol-induced liver damage in rats. *Journal of Agricultural and Food Chemistry*. 2010; 58: 3191-3196.