

A Review of Nutraceutical and Medicinal Properties of Rice (*Oryza sativa* L.)

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Abstract

Rice is the life of Asia and in many region of the world rice is an important part of their diet. For Sri Lankans rice is not just staple food and is embodied in the culture, religion, local ecology, biodiversity, health and nutrition. Rice is rich in genetic diversity and thousands of varieties grown around the world. However, with the introduction of high yielding fertilizer dependent rice very few varieties are grown around the world only considering yield and appearance of end product. Recently health benefits of rice attracted attention with the increase of life style related diseases like cancer, heart diseases and diabetics. Many laboratory studies have shown that rice products may have anti-cancer properties and the potential to treat other conditions such as diabetes, kidney stones and heart disease. This paper very briefly reviews the nutraceutical and medicinal properties of rice. Although, rice is considered as starchy food it comprises proteins with essential amino acids, fatty acids, fiber, several minerals and vitamins which are essential for normal body functions. Further it does not consist of cholesterol and salt and therefore rice is an excellent inclusion in healthy diet for hypertension person who have been advised to restrict to eat low salt diets. Researchers have been identified ancient medicinal systems in Sri Lanka as well as in other rice growing countries clearly identified medicinal properties of rice. Rice is the main constituent of oral rehydration solution for sick people from very ancient time to date and it has been showed that rice based rehydration solutions are better than glucose based solutions. In addition rice is use to treat various ailments such as diarrhea, vomiting, fever, skin diseases, stomach upsets, indigestion, blood pressure, diabetics, chronic constipation, cancer *etc.* Some of traditional uses of rice are supported by scientific studies. As an example antioxidant properties of rice have abilities to prevent cancer and low glycemic index of some traditional rice can reduce blood glucose levels and diabetics. Rice starch extracts and bran oil also use in range of cosmetics and hygiene products due to its nourishing and moisturizing effects on skin and hair. All these nutraceutical and medicinal properties of rice widely vary depending on varieties and studies showed that coloured rice like red and black rice and in traditional varieties are far better than high yielding rice cultivated today. Therefore, increasing micro nutrient levels of high yielding varieties combining traditional methods of growing and modern biotechnology will help to rice consumers for healthier, longer lives.

Keywords: *Rice, Nutritional, Medicinal, Health, Properties*

INTRODUCTION

Rice a monocot plant belongs to the genus *Oryza*, of the family Poaceae (grass family). The 2 cultivated species are *Oryza sativa* (L.) (Asian rice) and *Oryza glaberrima* (Steud.) (African rice) (Yves Agnoul *et al.*, 2012). As a result of genetic studies, many scientists believe that common wild rice, *Oryza rufipogon*, was the wild ancestor of *Oryza sativa* (Song *et al.*, 2005). However, there is still continuing debate over whether *Oryza rufipogon*, the perennial species, *Oryza nivara*, the annual species, or possibly both were the direct ancestors of *O. sativa* (Yves Agnoul *et al.*, 2012). Rice is one of the world's most important food crops eaten and grown across the globe (Chauhan, 2013). According to the FAO statistics rice is the most widely consumed staple food for

more than half of the world's population (Umadevi *et al.*, 2012). Therefore, rice is the grain with the second-highest worldwide production, after maize (Ahuja *et al.*, 2008; FAOSTAT, 2013). Cooking of rice is the more popular way of eating. Rice is an important source of energy and protein and according to Maclean *et al.* (2002) it provides 21% of the global human per capita energy needs and 15% of per capita protein requirements. However, in Asian countries 80% of their energy requirement is provided by rice (Ahuja *et al.*, 2008)

Rice is grown in more than a hundred countries (Hedge and Hedge, 2013), with approximately 710 million tons rice production in year 2011 (FAO, 2012). According to the IRRI statistics Asian people eat 80kg of rice every year (Zronik, 2006) however, this number can be much higher in some countries like Bangladesh, Laos, Cambodia. The preference of consumed rice is widely varied in different countries according to their taste, colour, texture and stickiness. For example, sticky rice in Japan, Taiwan, China, Korea and Egypt, dry flaky rice is eaten in South Asia and the Middle East; and red rice in Sri Lanka. Many countries have signature rice recipes, such as sushi, fried rice, curry, paella, risotto, pancit, and beans with rice. There are also many sweets and candies made from rice.

Rice has been cultivated in Sri Lanka since ancient times. Large reservoirs, irrigation systems and canals built up by ancient rulers mainly in dry zone of Sri Lanka prove that how rice cultivation was important to Sri Lankans. These constructions are still in use for rice production in dry zone of the country. Sri Lanka was termed as the 'Granary of the East' due to higher rice production during this period. From historical periods rice cultivation intertwine together of society, culture, rites, rituals and religion in the country. Many of Sri Lankans cultural activities embedded with rice cultivation and harvesting. According to the DOA (Department of Agriculture) statistics 34% of the total cultivated area supporting paddy cultivation in the Sri Lanka with an estimated extent sown rice to about 870,000ha and close upon 1.8 million farmer families are engaged in the paddy cultivation processes in the country (<http://www.agridept.gov.lk/index.php/en/crop-recommendations/808>). It has been also mentioned that Sri Lanka currently produces 2.7 million of rough rice annually and satisfied around 95% of the domestic requirement and on average in Sri Lanka rice provides 45% total calories and 40% protein requirement of Sri Lankan. DOA statistics further mentioned that the per capita rice consumption around 100kg/year depending on the price of rice, bread and wheat flour. Sri Lankan cuisine consists mainly of boiled or steamed rice served with spicy curries. However, there are many other well known traditional dishes like Kiribath (milk rice) and traditional sweets like kavum (oil cakes), Kokis (Deep Fried Batter of Flour & Coconut Milk) are made with rice and rice flour. According to these facts and figures it is clear that rice is intertwine with the life of Sri Lankans. This review mainly aims to discuss nutritional and medicinal properties of rice.

Nutritional value of rice

Nutritional values of rice have been extensively examined. The results of those studies revealed that different rice varieties have different nutritional composition. Some studies demonstrated high mineral, protein and anti-oxidant contents of traditional varieties than presently cultivating high yielding varieties. Until recently rice is considered as inexpensive and important source of energy with little amount of protein. Though small in amount rice protein has high nutritive value (reviewed in Umadevi *et al.*, 2012; Ahuja *et al.*, 2008). Rice fulfills 21% of the global human per capita energy needs and 15% of per capita protein requirements (Maclean *et al.*, 2002). Apart from carbohydrates and proteins rice consist small amount of fat and fiber (Juliano, 1985). Rice considered as healthy food as it does not consist cholesterol and salt (<http://www.amrice.com/6-4.cfm>). Rice is gluten free least allergic grain in the world providing healthful grain option for gluten free dilatory requirements (<http://www.amrice.com/6-4.cfm>).

The rice which removed only its outermost layer the hull is called as brown rice or whole grain rice. It has been proved that unlike white rice (Polished rice), brown rice consists more

nutrients and fiber intact. Therefore, compared with white rice, brown rice has a higher content of nutrients such as protein, minerals and vitamins and higher lysine content in its protein as most of these nutrients are present in greater quantities in outer layer than starchy endosperm (Umadevi *et al.*, 2012; Resurrección *et al.*, 1979; Eggum and Maningat, 1982). The nutrient contents of parboiled and raw rice, hand milled rice and milled rice using modern milling process are shown in table 1. Brown rice has a trace of sodium and fat, while white rice is sodium- and fat-free (<http://www.amrice.com/6-4.cfm>). Villareal and Juliano (1989) showed that pigmented brown rice has higher riboflavin but similar thiamine contents to non-pigmented IR rice. Further Srinivasa Rao (1976) also mentioned that the total carbohydrates and starch contents of milled red rice are lower than those of unpigmented milled rice in India. It has been showed that milled parboiled rice consists 3-4 times more thiamine, niacin and riboflavin than milled raw rice as during parboiling process some vitamins driven into the endosperm and starch in outer layer get gelatinized and which prevent removal of outer layer during milling process (Umadevi *et al.*, 2012).

Rice for energy

Rice is a great source of energy comprising around 90% carbohydrate. Rice uses as starchy staple food of more than half of world population. Starchy foods are important vehicles to carrying other nutrients such as protein, minerals (FAO, 1997). Rice consist high amount of resistant starch which encourage the growth of beneficial bacteria, keeping the bowl healthy (Umadevi *et al.*, 2012). Various studies revealed that milled white rice has high starch digestibility, however there are several other rice varieties reported around the world to have slower digestibility rates. Those varieties have low glycemic index and once we eat rice with low glycemic index feel “full” long after eating (PANAP, 2012). Glycemic index of rice mainly determined by proportion of amylase and the size and structure of the starch granules (PANAP, 2012). Certain traditional rice varieties in Sri Lanka, Philippines and from India (*Basmati* rice) are reported to have a low glycemic index (Ahuja *et al.*, 2008; PANAP, 2012). The starch digestibility of brown rice is very slow as well as some starch in brown rice is never turned into sugar at all (Dolson, 2009). Therefore it is being saying that eating white rice can cause blood sugars to spike increasing risk for developing diabetics and other disease as well. Harvard School of Public Health recently found that eating five servings per week of white rice increased the risk of diabetes (<http://www.hsph.harvard.edu>). Therefore, medical experts advocate replacing white rice with slowly digestible rice varieties especially for patients suffering from diabetes. One study in 2010 showed that the replacement of white rice by brown rice or other whole grains was associated with a lower risk of diabetes while another found that stabilized rice bran significantly reduced hyperglycemia and hyperlipidemia in both Type I and Type II diabetics (PANAP, 2012). This may be the reason that in early oriental writings, whole brown rice was mentioned as the perfect food.

Rice protein

Protein content of rice is very low but consist 8 essential amino acids in small quantities (Umadevi *et al.*, 2012). However, rice is considered as an important source of protein. Because studies showed that rice comprises higher amount of lysine and high protein digestibility (PANAP, 2012). The protein content of different rice varieties ranged from 4.3.to 18.2% averaging 9.5% (Maclean *et al.*, 2002).

Fatty acids of rice

Very small amount of fats are also consists in rice. Most of those fats are predominantly located in rice bran. Therefore, during milling process most of rice fats are removed (Babu *et al.*, 2009). As same as rice protein content, lipids and fatty acid content also varied in different rice varieties. A study in Philippines showed that traditional Philippine rice varieties have higher lipid content (2.3%) than improved cultivating rice varieties (2.0 to 2.1%) (PANAP, 2012). Rice bran oil

can have up to 80% unsaturated fatty acids (PANAP, 2012) depending on the varieties. Oleic acid and linoleic acid are the main two unsaturated fatty acids comprise in rice bran oil and these two lipids are considered as essential fatty acids which cannot be synthesized by humans (PANAP, 2012).

Minerals, vitamins and fiber

Rice is considered as an important source of minerals, vitamins and fiber even though rice is a starch food. These minerals and vitamins are essential component for normal cell metabolism, tissue and organ function and normal activity of heart. Although brown rice is unpopular among rice consumers it is an excellent source of the mineral manganese (Mn) (http://en.wikipedia.org/wiki/Brown_rice) which is needed for normal functioning of brain and nerves. The average Mn, potassium (K) and copper (Cu) levels of indica rice is lower than japonica rice (PANAP, 2012). They also found that the Cu content is lower in sticky rice whereas, K and Mn contents are higher in sticky rice (Jiang, 2008). It is also a good source of magnesium (Mg), zinc (Zn), iron (Fe), Cu, K and selenium (Se). The Se content of brown rice and of milled rice grown in Japan was reported to be 30 to 40 mg/g (Noda *et al.*, 1987). Distribution of Se is 13 percent in the hull, 15 percent in bran and 72 percent in milled rice (Ferretti and Levander, 1974). Another study also shown wide variation of Zn (2.1-39.4 µg/g) and Fe (5.1-441.5 µg/g) content among 220 rice varieties (reviewed in PANAP, 2012). Moreover another study conducted in Fe content of IRRI high yielding rice varieties showed that former varieties have 2.5 times higher Fe content than IRRI high yielding varieties (reviewed in PANAP, 2012). Same study was also shown that higher Zn content in traditional varieties than IRRI high yielding varieties. In general higher minerals and vitamins can be found in brown, red and black rice varieties than white and high yielding varieties (Frei and Becker, 2004). According to the Brar *et al.*, (2011) the wide variations of minerals and vitamins among rice varieties is attributed to plants metal regulating mechanisms such as absorption, movement and redistribution in plant tissues.

Energy-dispersive X-ray fluorescence spectrometry of seven IR rice indicated a mean Si content (wet basis) of $0.041 \pm 0.016\%$ for brown rice and $0.015 \pm 0.009\%$ for white rice (Villareal *et al.*, 1991). This silicon was located mainly in the outer layer of milled rice (Kennedy and Schelstraete, 1975). Brown unpolished rice consist four times more dilatory fiber which increase beneficial bacteria in digestive track and also prevent heart diseases and high blood pressure (PANAP, 2012).

Medicinal value

In traditional medicinal systems, it is mentioned that every plant on this earth is useful for human beings, animal and for other plants. Although it has not been scientifically proved there is a popular belief and have been described in several places that some rice varieties have medicinal properties. Even today ayurvedic practitioners in rice growing countries like Sri Lanka, India, Thailand, Malaysia, and Indonesia prescribe different rice varieties to cure ailments.

The French traveler and diamond merchant Jean-Baptiste Tavernier who visited India in 1646 observed that wheat eaters had more strength but rice eaters had more stamina (reviewed in Ahuja *et al.*, 2008). This implies rice is medicinally and nutritionally superior to wheat.

In Sri Lanka, farmers cultivate different traditional rice varieties to use to cure specific diseases such as *beheth heenati* to treat diabetes and snake bites; *hetada sahal* to prevent constipation; and *kalu henati* to reduce toxins in the body, revitalize body strength, and treat hepatitis. *Kuru wee* and *mada thawalu* varieties are also used by Sri Lankans to strengthen the immune system while *kurulu tuda* and *suwandel* are used to improve sexual strength, and *rathei* is applied in cases of urinary diseases (PANAP, 2012). In the Philippines, rice bran is extracted as excellent source of Vitamin B and traditionally used to prevent and cure beri-beri (Umadevi *et al.*, 2012; Ahuja *et al.*, 2008) and a nervous system ailment caused by thiamine (Vitamin B1)

deficiency (PANAP, 2012). In Kerala, India, the variety *Navara* is believed to have medicinal properties and is used to rejuvenate the nerves in paralytic conditions (Chopra, 1933).

Many scientists believe that high amount of insoluble fiber in whole grain rice are vital for protecting the body against cancerous cells. Several antioxidant such as tocopherols, oryzanol and tocotrienols also consist mainly in rice bran (Lloyd *et al.*, 2000). The extract from rice bran has been shown to contain safe and promising anti-cancer properties in selected cancer cell lines like breast, intestinal and pancreatic cancer and it is believed that this is due to its antioxidant capability (PANAP, 2012). Researchers have also found that tocopherols present in rice bran have ability to prevent or reverse blood clots and lesions that may lead to strokes or thrombosis (Frei and Becker, 2004).

Umadevi *et al.*, (2012) reviewed that rice-based oral rehydration solutions (ORS) have certain advantages over the standard glucose-based ORS to treat diarrhea. As a least allergenic food, rice is often recommended for people afflicted with irritable bowel syndrome. Sticky glutinous rice is often taken to treat stomach upsets, heart-burn and indigestion.

Rice extracts like starch and oil are used in a range of cosmetic and hygiene products. In indigenous medicinal systems of China mentioned that eating rice can contribute to the development of a calm and peaceful mind (Jack and Jack, 2003) and restore tranquility and peace to those who were easily upset (Umadevi *et al.*, 2012; PANAP, 2012). In India also use rice diet in combination with milk help for body balance. Amino acids in milk such as isoleucine and lysine are greatly strengthened by rice protein, forming stronger body-building blocks and lactic acid in milk with rice protein to increase the absorption of iron (Umadevi *et al.*, 2012).

And also Chinese people believe rice strengthens the spleen as well as stomach, increases appetite, and cures indigestion. They use dried, sprouted rice grains to aid in digestion, toning muscles and expel gas from the stomach and intestines and red rice yeast for various ailments (Umadevi *et al.*, 2012). In China black rice is believed to have a body-strengthening fraction and pharmaceutical value. Thus it is known as "blood strengthening rice", "drug rice" or "(con) tributed rice" (Li and Lai, 1989).

Traditional Malaysian medical system prescribe boiled rice 'greens' as an eye lotion and for use in acute inflammation of the inner body tissues and the application of dried powdered rice is recommended for skin ailments (Umadevi *et al.*, 2012). In Cambodia, the hulls of mature plants are considered useful for treating dysentery (Umadevi *et al.*, 2012). Medicinal properties of rice is changed with varies reasons such as growth stage, growing season, soil type, land preparation, planting method *etc.* and processing method also make considerable change in medicinal properties of rice (Ahuja *et al.*, 2008)

It has been proved that Phytate which is an enamel-protective factor is included in rice bran and the inclusion of rice bran or of a hot water extract of rice bran in human diets has a preventive action against dental caries (www.fao.org/docrep/t0567e/t0567e0g.htm).

Apart from above mentioned medicinal properties rice is used to cure various other ailments. Not only human but also for animals. As example rice is given to pregnant cows for safe delivery and healthy calf (Ahuja *et al.*, 2008)

High blood pressure

As mentioned earlier rice have low salt, cholesterol and fat providing healthy food for person suffering from hypertension. Some studies showed that there is a relationship in between high blood pressure and rice consumption as main food (Umadevi *et al.*, 2012). Further they explained that calcium in brown rice soothes and relaxes nerves system and it may help to reduce high blood pressure. Japanese researchers have discovered that germinated brown rice is better than ungerminated brown rice for people with high blood pressure and diabetes and for those suffering from obesity (reviewed in PANAP, 2012). Because germination activates all the dormant enzymes in rice, frees bound minerals to supply the sprout with the best nutrition and makes these

absorbable easily. They also found that germinated brown rice had higher lysine content, food fiber and anti-oxidants than white rice. Further gamma amino butyric acid (GABA) of germinated brown rice can normalize blood pressure, and control glycemia and cholesterol in the blood. It also has the potential to activate brain cell metabolism, prevent cancer and Alzheimer's disease, and eliminate anxiety disorders. Because of these various health benefits of germinated brown rice now being sold in Japanese and North American markets to cater to the health conscious (PANAP, 2012).

Digestive system diseases

Rice has been used to cure many diseases related to digestive track. The simplest use of rice as medicine since ancient time as gruel for diarrhea (Ahuja *et al.*, 2008). Umadevi *et al.* (2012) reviewed that low fiber content of rice soothe digestive track and can cure its disorders. As examples they mentioned that a thick congee of rice mixed with glassful of butter milk and a well-ripe banana given twice a day is a perfect diet for several digestive track disorders such as typhoid, gastric ulcer, stomach and intestinal cancer, colitis, diarrhea, dysentery, piles, rectal fissure, indigestion, in acute febrile diseases related to fever, hepatitis or inflammation of liver, jaundice, morning sickness, acute dilatation of the stomach, burning and indigestion due to hiatus hernia, excessive accumulation of the gas in the intestines. In addition powder of parboiled rice mixed with glassful of butter milk uses for children diarrhea (Umadevi *et al.*, 2012; Ahuja *et al.*, 2008). In Cambodia hull of mature grain use to treat dysentery (Ahuja *et al.*, 2008). The Chinese also believe that rice can strengthen stomach, increase appetite and cure indigestion and they use red rice yeast for various ailments (Ahuja *et al.*, 2008). In Sri Lanka whole grain rice is considered as a perfect medicine for constipation. The insoluble fiber from rice acts like a soft sponge that may be pushed through intestinal tract quickly and easily (Umadevi *et al.*, 2012). Rice water sweeten with sugar and acidulated with lime juice are recommended for bowl related problems (Ahuja *et al.*, 2008). Rice water is prepared by soaking rice in water or just boiling rice with excess water. In addition in India rice water is used as anupam (associated drink for medicine) (Ahuja *et al.*, 2008). Boiled rice water keep person fresh and energetic and also once drink rice water people does not feel thirsty for long time even after heavy physical works (Ahuja *et al.*, 2008). Rice water with pinch of salt given for very weak patients and infants in Sri Lanka also. Rice beer also use for various stomach ailments (Ahuja *et al.*, 2008).

Skin care

Before the advent of modern cream and talcum powder, rice powder and pastes used for various skin diseases. As examples for small-pox, measles and prickly heat a thick paste of rice flour apply on skin and it gives very cooling and soothing effect. In addition other inflammatory affections of the skin such as burns and scalds rice powder pastes are recommended to apply (Umadevi *et al.*, 2012). Indian Pharmacopoeia recommended rice water as excellent ointment for inflamed skins and also use for disuria (Ahuja *et al.*, 2008). Japanese young girls use special rice varieties to beautify their skins (Ahuja *et al.*, 2008). Rice can be used to improve skin conditions as an example boiled then mashed rice is applied to boils, sores, swellings and skin blemishes (www.kew.org/plantcultures/plants/rice_traditional_medicine.html). Rice extracts like starch and oil are used as an ingredient in a range of cosmetic and hygiene products. They are considered to have moisturizing and nourishing effects on the hair and skin (Lim, 2013). Extracts containing rice protein are added to hair products to give a feeling of volume and thickness to the hair. It is also reported to have moisturizing and anti-ageing properties (Lim, 2013).

Health benefits of traditional rice in Sri Lanka

With the introduction of high yielding varieties along with modern agronomic practices most traditional rice varieties were replaced by handful of high yielding rice strains from rice growing area in the world causing severe losses in rice genetic diversity. Different historical

records reveal that traditional rice varieties were revered for their nutritional and medicinal properties. In ancient Sri Lanka farmers cultivated different traditional varieties of rice, each with different nutrient content, texture, appearance, aroma, taste like characteristics. For example, *Heenati rice* was grown for lactating mothers. *Kanni murunga*, was grown for men going out to work in the fields, it gave them energy as it contained a lot of carbohydrates (<http://goviya.com/serendib05.htm>). *Suvandel* was cultivated for its extraordinary fragrance and monks who did not eat afternoon were given *Mawee*, as it possesses high protein content (<http://goviya.com/serendib05.htm>). *Kuruwee* (literally Small grains) is a sweet and soft red rice, *Murungakayan* is whole grain red rice that is high in nutritional value. *Gonabaru* is a very rare old variety of red rice that formed the staple diet of both peasant and king. *Dhikwee* is soft and wholesome red rice that is high in nutritional value.

During those days diseases like heart attack, high blood pressure, diabetics were almost unheard. Therefore, now there is an increasing trend to re-introduce traditional varieties with high medicinal value to paddy farmers. Although it is not scientifically proved some nutritional and medicinal properties of Sri Lankan traditional rice varieties has been documented (Table 2).

Traditional rice varieties have been conserved, developed and used by Sri Lankan farmers over a period of more than 3000 years. Hard scientific evidence exists to prove the rich nutritional values and therapeutic qualities of traditional rice varieties. A large number of traditional rice varieties have become extinct due to negligence of its importance.

CONCLUSION

International rice research institute in Philippines continuously conducting various researches to find out different ways to improve nutritional value of rice using traditional methods and modern technologies like biotechnology. Golden rice is one example which gives more vitamins A. In addition they are conducting research to produce rice varieties with higher amount of iron and zinc with bio fortification. As rice being one of most consumed cereal crop in the globe the improvement of its nutritional value will then increase health conditions of millions of peoples. On the other hand most of these nutritional and medicinal values of rice have not been scientifically proved. Therefore, research on those areas is also important. It was observed that the younger generation is less aware about these medicinal rice varieties than the older generations, so there is a strong need for documentation of this valuable information about the medicinal values of traditional rice varieties in the region.

REFERENCES

- Ahuja U, Ahuja SC, Thakrar R and Singh RK (2008) Rice- A Nutraceutical. Asian Agri-History. Vol 12(2):93-108
- Babu DP, Subhasree RS, Bhakayaraj R and Vidhyalakshmi R (2009) Brown rice beyond the Brar B, Jain S, Singh R and Jain RK (2011) Genetic diversity for iron and zinc contents in a collection of 220 rice (*Oryza sativa* L) genotypes. Indian J. Genet. 71(1): 67-73.
- Chauhan BS (2013) Management strategies for weedy rice in Asia. Los Baños (Philippines): International Rice Research Institute:1
- Chopra RN (1933) Indigenous drugs of India. Calcutta. 655 pp. Cited in E. Quisumbing, 1978. Medicinal plants in the Philippines. Quezon City, the Philippines, Katha Publishers.
- color reviving a lost health food – a review. American-Eurasian Journal of Agronomy 2(2): 67-72.
- Dolson L (2009) What you need to know about complex carbohydrates. <http://lowcarbdiets.about.com/od/nutrition/a/starch.htm>
- Eggum BO, Juliano BO and Maniñgat CC (1982) Protein and energy utilization of rice milling fractions by rats. Qual. Plant. Plant Foods Hum. Nutr. 31: 371 -376.
- Eggum BO, Juliano BO and Maniñgat CC (1982) Protein and energy utilization of rice milling fractions by rats. Qual. Plant. Plant Foods Hum. Nutr., 31: 371 -376.

- FAO (2012) Rice market monitor November 2012. Vol 15(4):
- FAO (1997) Carbohydrates in human nutrition. FAO Food and Nutrition Paper – 66. Report of joint FAO/WHO expert consultation.
<http://www.fao.org/docrep/W8079E/W8079E00.htm>
 FAOSTAT Retrieved December 18, 2013
- Ferretti RJ and Levander OA (1974) Effect of milling and processing on the selenium content of grains and cereal products. *J. Agric. Food Chem.*, 22: 1049-1051.
- Frei M and Becker K (2004) On rice, biodiversity and nutrients. Institute of Animal Production in the Tropics and Subtropics. University of Hohenheim, Stuttgart.
- Hegde S and Hegde V (2013) Assessment of Global Rice Production and Export Opportunity for Economic Development in Ethiopia. *International Journal of Science and Research*. Vol 2(6): 257-260
http://agritech.tnau.ac.in/postharvest/pht_cereal_rice.html. Retrieved in January 26, 2014
http://en.wikipedia.org/wiki/Brown_rice. Retrieved in January 30, 2012
<http://goviya.com/serendib05.htm> retrieved in January 31, 2014
<http://www.agridept.gov.lk/index.php/en/crop-recommendations/808>. Retrieved by January 26, 2014
<http://www.amrice.com/6-4.cfm>. Retrieved by January 26, 2014
<http://www.hsph.harvard.edu> retrieved in January 31, 2014
- Jack G and Jack A (2003) Healing with rice: 108 special dishes, drinks, compresses and other home remedies. Amberwaves. 7p.
- Jiang SL, Wu JG, Nguyen B, Thang Feng Y, Yang XE and Shi CH (2008) Genotypic variation of mineral elements contents in rice (*Oryza sativa*L.). *Eur Food Res Technol* 228:115–122
- Juliano BO (1985) Factors affecting nutritional properties of rice protein. *Trans. Natl. Acad. Sci. Technol. (Philipp.)* 7: 205-216.
- Kennedy BM and Schelstraete M (1975) A note on silicon in rice endosperm. *Cereal Chem.*, 52: 854856.
- Li BJ and Lai LZ (1989) The study on the breeding of "black superior rice" by using biotechniques. *Proc. 6th Int. Congr. SABRAO*, 289291p.
- Lim TK (2013) *Edible Medicinal And Non-Medicinal Plants: Volume 5*, Springer Dordrecht Heidelberg New York. 338
- Lloyd BJ, Siebenmorgen TJ and Beers KW (2000) Effects of commercial processing on antioxidants in rice bran. *Cereal Chem.* 77(5):551-555
- Maclean JL, Dawe D, Hardy B and Hettel GP (2002). *Rice almanac: source book for the most important economic activity on earth*. Wallingford, Oxon. CABI Publishing.
- Noda K, Hirai S and Dambara H (1987) Selenium content of brown rice grown in Japan. *Agric Biol. Chem.*, 51: 2451 -2455
- PANAP (Pesticide Action Network Asia and the Pacific) 2012 P.O. Box: 1170, 10850 Penang, Malaysia.
- Resurrección AP, Juliano BO and Tanaka Y (1979) Nutrient content and distribution in milling fractions of rice grain. *J. Sci. Food Agric.* 30: 475-481.
- Song Z, Bo li Chen J and Bao-rong Lu (2005) Genetic diversity and conservation of common wild rice (*Oryza rufipogon*) in China. *Plant species Biology* 20: 83-92
- Srinivasa Rao P (1976) Nature of carbohydrates in red rice varieties. *Plant Foods Man.* 2: 69-74
- Umadevi M, Pushpa R, Sampathkumar KP and Bhowmik D (2012) Rice-Traditional Medicinal Plant in India. *Journal of Pharmacognosy and Phytochemistry*. Vol 1(1):5-12
- Villareal CP and Juliano' BO (1989) Variability in contents of thiamine and riboflavin in brown rice crude oil in brown rice and bran-polish and silicon in hull of IR rice. *Plant Foods Hum. Nutr.* 39: 287-297.

- Villareal CP, Maranville JW and Juliano BO (1991) Nutrient content and retention during milling of brown rice from the International Rice Research Institute. *Cereal Chem.*, 68: 437-439.
www.fao.org/docrep/t0567e/t0567e0g.htm retrieved in January 31, 2014
www.kew.org/plant-cultures/plants/rice_traditional_medicine.html retrieved in January 31, 2014
 Yves A, Samadori SH, Biao M, Sié RS, Vodouhè and Ahanchédé A (2012) The African rice *Oryza glaberrima* Steud: Knowledge Distribution and Prospects. *International Journal of Biology*. Vol 4(3):158-180
 Zronik JP (2006) Rice lands. Eds. A. Morganelli and LM Nielsen In *The biography of rice*. Crabtree publishing company. Pp10

Tables

Table 1: Nutrient contents of parboiled, hand pounded and milled rice

Food	Energy K.cal	Protein g	Fat g	Carbohydrates g	Calcium mg	Iron mg	bCarotene mcg	Thiamine mg	Riboflavin mg	Niacin mg
Rice, parboiled, hand pounded	349	8.5	0.6	77.4	10	2.8	9	0.27	0.12	4.0
Rice, parboiled, milled	346	6.4	0.4	79.0	9	1.0	-	0.21	0.05	3.8
Rice, raw, hand-pounded	346	7.5	1.0	76.7	10	3.2	2	0.21	0.16	3.9
Rice, raw, milled	345	6.8	0.5	78.2	10	0.7	0	0.06	0.06	1.9

Source: http://agritech.tnau.ac.in/postharvest/pht_cereal_rice.html

Table 2:- Some medicinal uses of traditional rice varieties

Name of rice variety	Medicinal uses
<i>Suwadal</i>	Delicious white rice with an exquisite aroma and milky taste. Therefore, it has been used for festive occasions and ceremonies. In ancient Sri Lanka it has been believed that suwadal promote fair and glowing skin; enhance the functioning of the excretory system, male sexual potency, vocal clarity and helps control diabetes. It is also said to support a balanced growth of body.
<i>Rathdel</i>	A delicious red rice which provides relief to those suffering from cirrhosis; helps flush toxic excretory matter and cools the body; recommended for rashes caused by mental stress; provides relief for ailments in the urinary system and preventing the formation of stones in the bladder and gall bladder. Porridge and soup made with rathdel can help fight against viral fever while roasted and ground rathdel raw rice tempered with ghee has been reported as an effective remedy for purging. Porridge made out of rathdel rice, sarana (<i>Boerhavia diffusa</i>), 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 male sexual potency.
<i>Kaluheenati</i>	Dark, fine grained highly nutritious red rice perfect for daily consumption. It is particularly recommended for lactating mothers and said to enhance male sexual potency and physical strength. Its high fibre content helps regulate bowel movement. It is effective in keeping diabetes under control as well as controlling the toxic effects of snake bites. Porridge made from kaluheenati rice is highly recommended for hepatitis patients
<i>Ma-Wee</i>	Red rice variety with scrumptious texture and low in carbohydrates. Therefore, Ma Wee helps maintain a trim, shapely figure. It provides relief for burning sensation and cools the body. Ma-Wee rice consumed together with meat can reduce alcohol intoxication. It is recommended for tuberculosis, constipation, haemorrhoids and cardiovascular disease. Ma Wee also controls corpulence. It helps control diabetes and is an effective remedy for purging.
<i>Madathawalu</i>	Highly recommended in Ayurvedic treatment to strengthen the immune system.
<i>Hetadha Wee</i>	red rice variety that helps control diabetes and provides relief for burning sensations and cools the body. It relieves ailments caused by biological imbalances; improves physical strength and an effective remedy for purging, blood vomiting and bleeding disorders.
<i>Pachchaperumal</i>	Short grain red rice rich in nutrients and protein. When cooked takes on a deep rich burgundy colour. Pachchaperumal is recommended for diabetes and cardiovascular disease.
<i>Kuruluthuda</i>	Delectable and nutritious red rice variety which is rich in proteins and fibre. It has a pleasant taste. It is said to improve bladder functioning, enhance male sexual potency and help evade impotency.

Source :- www.rensriilanka.org/tradrice.html

Table 3- Some nutritional properties of traditional rice

Nutritional Information	Suwadel	Kaluheenati	Ma-wee	Pachchaperumal	Kuruluthuda
Starch	90%	75%	84.5%	80.5%	83.4%
Crude Protein	7%	8.5%	9.4%	6.4%	6.7%
Crude fat	0.7%	3%	3.6%	3.2%	0.9%
Crude Fiber	0.1%	0.8%	1.1%	1%	0.4%
Ca (mg/100g)	0.9	2.2			
Fe (mg/100g)	2	2.3			
Vitamin B	trace	Rich			

Source:- www.saaraketha.com