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Rice nutritional and medicinal properties: A review article

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Abstract
Rice is most common cereal, serving as a stable food for approximately half of the global population. Over 2 billion people in Asia alone derive 80% of their energy needs from rice, which contains 80% carbohydrates, 7–8% protein, 3% fat, and 3% fibre. Drug molecule from food always been preferred. Natural molecule may have better physiological compatibility with lesser or no toxic effect. Several researches are going on different varieties of rice around the globe, number of publications from several countries showed the potent effect of different varieties of rice against diabetes, hyperlipidemia, cancer, inflammation etc. Rice possesses lesser antioxidant potency or has less antioxidant molecule compared with other cereals. Therefore, rice is a good candidate for natural sources of antioxidants and other medicinal properties and may hold the potential for the development of rice based functional foods, drugs, food preservative, pharmaceuticals and cosmetic products.

Keywords: Rice, Nutritional contents, Medicinal properties and Human health

Introduction
Rice is the staple food of over half of the world's population and 90% of Asians. Rice is known as the grain of life, and is synonymous with food for Asians. In addition to being a staple food and an integral part of social rites, rituals, and festivals in almost all Asian countries, it has a medicinal value too, which was clearly recognized by the medicine systems of the region centuries ago. Ancient Asian civilizations have long valued the importance of rice in sustaining human health and nutrition. India has a wealth of medicinal plants, most of which have been traditionally used in Ayurveda, Unani systems of medicines and by tribal healers for generations. In ancient Indian literature it is clearly mentioned that every plant on this earth is useful for human beings, animals and for other plants (Oudhia 1999) [26]. In Ayurveda the medicinal values of rice have been described: rice is considered to be acrid, oleaginous, tonic, aphrodisiac, fattening, diuretic and useful in biliousness (Caius 1986) [5].
The last 20 years have witnessed a major change in the disease pattern in India, which clearly follows a generalized global trend. The shift from communicable diseases to lifestyle-related diseases is apparent not only in urban India, but in rural India too. Lifestyle-related diseases such as heart attack, diabetes, and cancer have begun to assume epidemic form over the last two decades, with experts attributing it to bad genes. International studies have shattered this myth, putting the blame on sloppy lifestyles, faulty diets, and high stress levels.
Over the last decade, globalization and rampant consumerism have triggered a flood of culinary ideas from all parts of the world, resulting in a never-before platter of gourmet delights. While this has satisfied the taste buds of Indian consumers, it has also brought in its wake a disturbing increase in lifestyle-related diseases. The alarm bells have already started ringing for diabetes and heart problems. Newly developed medicines are costly, have side effects, and burden the state exchequer. Lifestyle-related diseases therefore represent a serious problem that is expensive to control, apart from the heavy out-of-pocket expenditure burden on the common man.
Indian nutritionists have often raised a hue and cry against the growing public inclination towards junk food, and have been constantly recommending the use of green, healthy, and functional food. Extensive studies are being made to find novel food-based approaches to lowering the incidence and severity of lifestyle-related diseases. The focus is on mineral contents, antioxidant properties, and the glycemic index of food. Against this backdrop, rice (*Oryza sativa*) holds promise as a medicinal and health food.

Rice Uses
1) **Staple food:** Rice is used as a staple food by more than 60 percent of world population.

Cooking of rice is a most popular way of eating.

2) **Starch:** Rice starch is used in making ice cream, custard powder, puddings, gel, distillation of potable alcohol, etc.
3) **Rice Bran:** It is used in confectionery products like bread, snacks, cookies and biscuits. The defatted bran is also used as cattle feed, organic fertilizer (compost), and medicinal purpose and in wax making.
4) **Rice Bran Oil:** Rice bran oil is used as edible oil, in soap and fatty acids manufacturing. It is also used in cosmetics, synthetic fibers, detergents and emulsifiers. It is nutritionally superior and provides better protection to heart.
5) **Flaked Rice:** It is made from parboiled rice and used in many preparations.
6) **Puffed rice:** It is made from paddy and used as whole for eating.
7) **Parched Rice:** It is made from parboiled rice and is easily digestible.
8) **Rice Husk:** It is used as a fuel, in board and paper manufacturing, packing and building materials and as an insulator. It is also used for compost making and chemical derivatives.
9) **Rice Broken:** It is used for making food item like breakfast cereals, baby foods, rice flour, noodles, rice cakes, etc. and also used as a poultry feed.
10) **Rice straw:** Mainly used as animal feed, fuel, mushroom bed, for mulching in horticultural crops and in preparation of paper and compost.
11) **Paddy as a Seed:** The paddy is used as seed.

Rice Nutritional &Health Benefits

Rice is the second most widely consumed cereal in the world next to wheat. It is the staple food for two thirds of the world's population. Over 2 billion people in Asia alone derive 80% of their energy needs from rice, which contains 80% carbohydrates, 7-8% protein, 3% fat, and 3% fibre (Juliano, 1985). Table1 and Table 2 show the nutrient contents of brown rice and also comparison with other cereals and tuber crops.

Table 1: Proximate composition of cereal and tuber staple foods

Food	Moisture %	Protien (gNx6.25)	Crude fat (g)	Available carbohydrates (g)	Fibre (g)			Crude ash (g)	Energy (kJ)	Energy (kcal)
					Dietary	Water insoluble	Lignin			
Brown rice	14.0	7.3	2.2	71.1	4.0	2.7	0.1	1.4	1610	384
Wheat	14.0	10.6	1.9	61.6	10.5	7.8	0.6	1.4	1570	375
Maize	14.0	9.8	4.9	60.9	9.0	6.8	0	1.4	1660	396
Millet	14.0	11.5	4.7	64.6	37	2.3	0	1.5	1650	395
Sorghum	14.0	8.3	3.9	57.4	13.8	12.4	3.0	2.6	1610	384
Rye	14.0	8.7	1.5	60.9	13.8	8.4	14	1.8	1570	375
Oats	14.0	9.3	5.9	63.0	5.5	39	0	2.3	1640	392
Potato	77.8	2.0	0.1	15.4	2.5	1.9	0	1.0	294	70
Cassava	63.1	1.0	0.2	31.9	2.9	2.2	0	0.7	559	133
Yam	71.2	2.0	0.1	22.4	3.3	2.6	0	1.0	411	98

Source: Souci *et al.*, 1986, Eggum 1969, 1977 & 1979
Zn level of cassava and Yam from Bradbury & Holloway 1988

Table 2: Vitamin and mineral content of cereal and tuber staple foods (per 100g)

Food	Carotene (mg)	Thiamine (mg)	Riboflavin (mg)	Niacin (mg)	Ascorbic acid (mg)	Vitamin E (mg)	Iron (mg%)	Zinc (mg%)
Brown rice	0	0.29	0.04	4.0	0	0.8	3	2
Wheat	0.02	0.45	0.10	3.7	0	1.4	4	3
Maize	0.37	0.32	0.10	1.9	0	1.9	3	3
Millet	0	0.63	0.33	2.0	0	0.07	7	3
Sorghum	10.0	0.33	0.13	3.4	0	0.17	9	2
Rye	0	0.66	0.25	1.3	0	1.9	9	3
Oats	0	0.60	0.14	1.3	0	0.84	4	3
Potato	0.01	0.11	0.05	1.2	17	0.06	0.8	0.3
Cassava	0.03	0.06	0.03	0.6	30	0	1.2	0.5
Yam	0.01	0.09	0.03	0.6	10	0	0.9	0.7

Source: Souci, *et al.*, Eggum 1969, 1977 & 1979

Health benefits

Excellent source of carbohydrates: Rice is a great source of complex carbohydrates. Carbohydrates are broken down to glucose, most of which is used as energy for exercise and as essential fuel for the brain slow starch digestion (with low glycemic index), attributed to a high proportion of amylase and the size and structure of the starch granules. Rice eaters who are Type II diabetics would be better off eating slowly digestible rice varieties than white rice. Brown rice, for instance, has a slow starch digestibility too and some starch is never turned into sugar at all and reaches the large intestine intact (Dolson *et al.*, 2009) [9]. One study in 2010 (Qi *et al.*, 2010) [28] showed that the replacement of white rice by brown rice or other whole grains was associated with a lower risk of diabetes while another (Qureshi *et al.*, 2002) [29] found that stabilized rice bran significantly reduced hyperglycemia and hyperlipidemia in both Type I and Type II diabetics. In any event, Type II diabetics should still avoid having too much carbohydrate in their diet (Fri and Backer, 2004). Carbohydrate digestion and utilization rates vary with each individual, depending on his/ her energy needs. Carbohydrate foods are important vehicles carrying proteins, micronutrients and other food components (FAO, 1997) [13]. It should be valued for its nutritional and medicinal properties and ought to be consumed with other food such as vegetables, fish, meat and fruits to ensure a diverse diet, nutrition and good health.

Low fat, Low salt, No cholesterol: Rice is an excellent food to include in a balanced diet. Rice has no fat, no cholesterol and is sodium free. Rice lipids, which include fatty acids, are

predominantly located in rice bran which is removed during milling. Depending on the variety, rice bran oil can have up to 80%unsaturated fatty acids (Fri and Backer, 2004). Oleic acid and linoleic acid constitute the unsaturated fatty acids in rice oil. These essential fatty acids, which cannot be synthesized by humans, are important in maintaining the function of cell membranes and the nervous system.

Rice for protein: Rice is an important source of protein. It has a high proportion of lysine and high protein digestibility. Rice protein, which comprises up to eight per cent of the grain, has a special benefit as it has eight of the essential amino acids in adelicately balanced proportion. A complete internal rejuvenation takes place when rice protein is metabolized into health-building amino acids. These amino acids build resilient muscles which comes back to its original form after stretching and bending, healthy skin and hair and clearer eyesight and nourish the heart and lungs, tendons and ligaments, brain, nervous system and glandular network.

Rice for Vitamins: The B-complex vitamins, especially thiamin, riboflavin and niacin offered by natural brown rice promote youthful energy and nourishment to skin and blood vessels.Rice bran also contains beneficial anti-oxidants like tocopherols and tocotrienols (of the Vitamin E family) and oryzanols (Lloyd *et al.*, 2000) [24]. Researchers have investigated the anti-cancer activities of tocopherols (Kline *et al.*, 2004) [22] tocotrienols (Lloyd *et al.*, 2000) [24] and the ability of oryzanols to reduce cholesterol absorption (Lloyd *et al.*, 2000) [24]. Researchers have also found that tocotrienol present in rice bran can prevent or reverse blood clots and lesions that may lead to strokes or thrombosis (Fri and Backer, 2004). In addition, the bran of red and purple rice is rich in anthocyanins and tannins which possess antioxidant and anti-inflammatory properties. Tannins have been investigated for their anti-bacterial effects and potential to prevent cancer and cardiovascular diseases.

Rice for Minerals: Red and black rice have been found to be rich in iron (Fe), zinc (Zn) and minerals (Ahuja *et al.*, 2000). Zinc and iron are needed by the human body for enzymatic processes and haemoglobin production, respectively. If zinc is deficient, symptoms such as diarrhoea, weight loss and infection appear. If left untreated, zinc deficiency can be fatal. Similarly, iron deficiency can be detrimental to health, leading to anaemia with symptoms of brittle hair, brittle fingernails and fatigue. Rice is also a source of potassium (K), an important mineral needed by the body for normal metabolism, cell, tissue and organ function, muscle growth, and normal activity of the heart. Rice also contains manganese (Mn) and copper (Cu) in trace amounts. Manganese is needed for normal functioning of the brain and nerves while copper is needed for enzyme production for normal body function. An abundance of minerals in natural brown rice help to nourish the hormonal system heal wounds and regulate blood pressure. Rice also offers iron to enrich the bloodstream and phosphorus and potassium to maintain internal water balance along with other nutrients. Rice thus helps restore internal harmony.

Compounds in Rice Bran for Prevention of Chronic Disease

Rice bran also contains essential amino acids (tryptophan, histidine, methionine, cysteine, and arginine) and micronutrients (eg, magnesium, calcium, phosphorous, manganese, and 9 B-vitamins), all of which may work together for health promotion. Selected compounds from rice bran have been investigated for prevention and control of chronic disease via multiple mechanisms **(**table 3**)**.

Table 3: Selected bioactive compounds in rice bran evaluated for their properties with regard to prevention of chronic disease

Rice bran compound	Disease prevention activity
Ferulic acid	Antioxidant, chemopreventive, anti-inflammatory and lipid-lowering effects
ϒ-Oryzanol	Antioxidant, chemopreventive, anti-inflammatory and lipid-lowering effects
Inositol hexaphosphate	Blocks cancer growth and signaling
Compesterol	Antiangiogenic
β-Sitosterol	Blocks cholesterol
Linoleic acid	Anti-inflammatory
α-Tocopherol	Inhibit lipid peroxidation and intracellular signaling
Tocotrienol	Inhibit lipid peroxidation and intracellular signaling
Salicylic acid	Anti-inflammatory
Caffeic acid	Gastrointestinol microbe interactions
Caumaric acid	Antimutagenic, inhibit the cell cycle, antioxidant and chemopreventive
Tricin	Antimutagenic, inhibit the cell cycle, antioxidant and chemopreventive

Processing Nutritious rice

Aside from differences in nutritional values of different rice varieties, processing also affects the nutrient quality of rice (table 4, 5 & 6). White (milled) rice predominates in the market and Asian diets. Unfortunately, milling and polishing destroy 67% of Vitamin B3, 80% of Vitamin B1, 90% of Vitamin B6, 50% of manganese, 50% of phosphorus, 60% of iron, and all the dietary fibre and essential fatty acids (Babu *et al.*, 2009) [3]. In contrast, brown unpolished rice has four times more dietary fibre which increases beneficial bacteria in the large intestine, aiding digestion and protecting against heart disease and high blood pressure. A team of Japanese researchers found that germinated brown rice had higher lysine content, food fibre and anti-oxidants than white rice. Germinated brown rice, with rich gamma amino butyric acid (GABA), appears to be effective in normalizing blood pressure, and controlling glycemia and cholesterol in the blood. It has the potential to activate brain cell metabolism, prevent cancer and Alzheimer's disease, and eliminate anxiety disorders.

Table 4: Nutrient contents rough rice and its milling fractions

Rice fraction	Crude protein (gNx5.95)	Crude fat (g)	Crude fibre (g)	Crude ash (g)	Available carbohydrates (g)	Neutral detergent fibre (G)	Energy content		Density (g/ml)	Bulk density (g/ml)
							(kJ)	(hcal)		
Rough rice	5.8-7.7	1.5-2.3	7.2-10.4	2.9-5.2	64-73	16.4	1580	378	1.17-1.23	0.56-0.64
Brown rice	7.1-8.3	1.6-2.8	0.6-1.0	1.0-1.5	73-87	2.9-3.9	1520-1610	363-385	1.31	0.68
Milled rice	6.3-7.1	0.3-0.5	0.2-0.5	0.3-0.8	77-89	0.7-2.3	1460-1560	349-373	1.44-1.46	0.78-0.85
Rice bran	11.3-14.9	15.0-19.7	7.0-11.4	6.6-9.9	34-62	24-29	670-1990	399-476	1.16-1.29	0.20-0.40
Rice hull	2.0-2.8	0.3-0.8	34.5-45.9	13.2-21.0	22-34	66-74	1110-1390	265-332	0.67-0.74	0.10-0.16

Sources: Juliano, 1985; Pedersen & Eggum, 1983.

Table 5: Vitamin and mineral content of rough rice and its milling fractions at 14 percent moisture

Rice fraction	Thiamine (mg)	Riboflavin (mg)	Niacin (mg)	α Tocopherol (mg)	Calcium (mg)	Phosphorus (g)	Phytin P (g)	Iron (mg)	Zinc (mg)
Rough rice	0.26-0.33	0.06-0.11	2.9-5.6	0.90-2.00	10-80	0.17-0.39	0.18-0.21	1.4-6.0	1.7-3.1
Brown rice	0.29-0.61	0.04-0.14	3.5-5.3	0.90-2.50	10-50	0.17-0.43	0.13-0.27	0.2-5.2	0.6-2.8
Milled rice	0.02-0.11	0.02-0.06	1.3-2.4	0.75-3.00	10-30	0.08-0.15	0.02-0.07	0.2-2.8	0.6-2.3
Rice bran	1.20-2.40	0.18-0.43	26.7-49.9	2.60-13.3	30-120	1.1-2.5	0.9-2.2	8.6-43.0	4.3-25.8
Rice hull	0.09-0.21	0.05-0.07	1.6-4.2	0	60-130	0.03-0.07	0	3.9-9.5	0.9-4.0

Sources: Juliano, 1985: Pedersen & Eggum, 1983.

Table 6: Amino acid content of rough rice and its milling fractions at 14 percent moisture (9 per 16 9 N)

Rice fraction	Histidin	Isoleucin	Leucine	Lysine+cysteine	Methionin+ tyrosin	Phenylalanin	Threonine	Tryptophan	Valine	Amino acid score[a]
Rough rice	1.5-2.8	3.0-4.8	6.9-8.8	3.2-4.7	4.5-6.2	9.3-10.8	3.0-4.5	1.2-2.0	4.6-7.0	55-81
Brown rice	2.3-2.5	3.4-4.4	7.9-8.5	3.7-4.1	4.4-4.6	8.6-9.3	3.7-3.8	1.2-1.4	4.8-6.3	64-71
Milled rice	2.2-2.6	3.5-4.6	8.0-8.2	3.2-4.0	4.3-5.0	9.3-10.4	3.5-3.7	1.2-1.7	4.7-6.7	55-69
Rice bran	2.7-3.3	2.7-4.1	6.9-7.6	4.8-5.4	4.2-4.8	7.7-8.0	3.8-4.2	0,6-1.2	4.9-6.0	83-93
Rice hull	1.6-2.0	3.2-4.0	8.0-8.2	3.8-5.4	3.5-3.7	6.6-7.3	4.2-5.0	0.6	5.5-7.5	66-93

Sources: Juliano, 1985; Pedersen & Eggum, 1983.

Varieties with medicinal value

Different rice varieties have different nutritional composition. Current findings point to the importance of landraces/ traditional rice varieties for their high mineral, protein and anti-oxidant contents. Studies have demonstrated beneficial qualities such as the high biological value of amino acids in rice, high content of essential fatty acids and selenium, and anti-hypertension effects. However, such knowledge remains unknown to most consumers who are conditioned to equating good quality rice with white polished rice, depriving to have them of the potential health benefits provided by rice diversity At present, a number of varieties with medicinal properties are grown and used in various states of India (Table 7).

Table 7: Medicinal uses of rice varieties in the various states of India:

State	Rice variety	Medicinal use
Madhya Pradesh	*Aalcha*	Pimples, small boils in infant
	Baissor	Chronic headache, epilepsy
	Gathuwanor	Rheumatism
	Karhani	Paralysis
	Kalimooch	Skin diseases
	Maharaji	Post-natal tonic for women
	Bhajari	Renewal in placenta in cows
	Dhanwar	Renewal in placenta in cows
Orissa	*Mehar*	Post-natal tonic for women
	Saraiphol	Post-natal tonic for women
Karnataka	*Kari Bhatta*	Skin infections, increase milk in women
	Karikagga	Cooling effect
	Atikaya	Health tonic
	Mullarya	Cooling effect
Kerala	*Nivara*	Cure of *tridoshas*
	Erumakkari	Cough
Himachal Pradesh and Uttar Pradesh	*Katheri*	Post- delivery restoration of size of reproductive organs
	Kaflaya	Leucorrhea
	Matali, Lal Dhan	High blood pressure, fever

Kerala is rich in traditional rice varieties, which are conserved and developed by the tribaland rural farmers of the State. The traditional rice varieties exhibit a wide range of peculiarities such as tolerance to drought, flood, pests, diseases, salinity and alkalinity. Kerala is endowed with speciality rice varieties rich in nutritional values, cultural values, fine aroma and medicinal properties.

Table 8: Medicinal rice known in cultivation in Kerala

Variety	Days to maturity	Places grown
Erumakkari	120-130	Thrissur, EKM
JaathiSughi	120	Kasargode
JeerakaChembavu	120	TVM
KaruthaChembavu	120	TVM
Kamaal	120	Kannur
Kolaran	85-90	Kasargode
KunjiNellu	120	Kannur
Nallachennellu	120	Kannur
Naron	60	Kannur
Navara	60-90	All over Kerala
Vadakkan	85-90	Kannur
Vatton	90	Thrissur, Palakkad
Chennellu	120	Wayanad

The deep red colored and long-sized rice of Chhattisgarh and Jharkhand are reported to be more nutritious than the red, white, and coarse-grained rice. Red rice varieties such as *Bhama*, *Danigora*, *Karhani*, *Kalamdani*, *Ramdi*, *Muru*, *Hindmauri*, and *Punaigora* are reported to be more nutritious; after consuming these rice only once, a person can work in the field for a whole day without feeling hungry. The cooked rice starchy water (locally called *mar* or *maand*) of red rice varieties helps keep a person fresh and energetic. Even after long hours of hard physical work, a person does not feel thirsty. (Das and Oudhia, 2001) [8]

Medicinal values rice germplasm in Chhattisgarh

In Chhattisgarh rice is widely cultivated and the region is known as 'Rice bowl of India'. Rice germplasm is a heritage of mankind that has evolved through several millennia of cultivation and selection by our farming ancestors. Biodiversity Unit of department of Genetics and Plant Breeding, College of Agriculture, IGKV, Raipur is maintaining more than 23000 rice germplasm accessions. The task involved in conserving the rice germplasm for productive purposes are important, challenging and difficult. Twelve medicinal rice germplasms on the farmers perceptions are conserved and documented.

1) Gathuwan: - It was collected from Abhanpur block, Raipur district (Chhattisgarh.). Its lemma-palea colour is red and kernel colour is white, translucent. Rice is useful for patients suffering from Joint's pain in human beings.
2) Bhejari:- It was collected from Simga block, Raipur district (Chattisgarh). Its lemma-palea colour is straw coloured and kernel colour is white, translucent. Its paddy grains mixed with crushed linseed grains and semi cooked, fed to a cow & She-buffalo after delivery for easy removal of placenta.
3) Maharaji:- Place of collection is Ghughari block, Mandla district (Madhya Pradesh). Its lemma-palea colour is brown. Kernel colour is white, translucent & scented. Rice is useful for removing weakness of mother, caused by bleeding after delivery.
4) Sarai Phool:- It was collected from Nainpur block, Mandla district (Madhya Pradesh). Colour of its lemma-palea is straw coloured and Kernel colour is white, translucent. Rice is useful for removing weakness in Human beings.
5) Danwar:- It was collected from Sarona block, Sukma district (Chhattisgarh). Colour of its lemma-palea is light purple, with long and partial awning. Kernel colour is red. Its paddy grains mixed with crushed linseed grains and semi cooked, fed to a cow & She-buffalo after delivery for easy removal of placenta.
6) Baisur:- Place of collection is Dongargarh block, Rajnandgaon district (Chhattisgarh). Its lemma-palea colour is purple with purple awns. Kernel colour is white, translucent. The smoke from burning husk (Chaff), on inhaling cures half side headache (migraine) & epilepsy in human beings.
7) Resari:- It was collected from Chouki block, Rajnandgaon district (Chhattisgarh). Its lemma-paleacolour is red. Kernel colour is white and chalkiness is present. Its over cooked rice with enough water (semi-liquid) fed to cattle for removal of weakness. The tribals used Murra of this variety, mixed with the bark of Phans plant, to cure prolonged cough.
8) Laycha - It was collected from Sarona block, Sukma district (Chhattisgarh). It is useful for pregnant mother as a preventive measure for getting healthy child.
9) Soth:- It was collected from Simga block, Baloda Bazar-Bhatapara district(Chhattisgarh). Rice is useful for patients suffering from coldness.
10) Sul Dhan:- It was collected from Deobhog block, Gariyabandh district (Chhattisgarh). Rice is useful to recover stomach problem in human beings.
11) Mehar Dhan:- It was collected from Kondagaon block, Kondagaon district (Chhattisgarh). Rice is useful for diabetic patients.
12) Karhani:- It was collected from Pali block, Sahdol district (M.P.). Rice is useful for patients suffering from paralysis.

Present research

At present, rice is being seen under a different light – beyond its stereotype of staple food and primary source of carbohydrate or starch. Its mineral content, starch quality, glycemic index, and antioxidant activity has made rice unique among cereals. It has been found that, in comparison with other sources (wheat, potato, and maize), rice starch is nearly completely absorbed by the human body (Strocchi and Levitt, 1991). Positive qualities of high digestibility of starch, high biological value of amino acids, high content of essential fatty acids and selenium, and anti-hypertension effect have been confirmed scientifically. Rice can therefore be described now as a functional food. Rice-based oral rehydration solutions (ORS) have been proved effective in decreasing stool output and improving intestinal absorption in acute diarrhea. Rice extracts were found to decrease intestinal losses by actively inhibiting chloride channels (Goldberg and Saltzman, 1996). Rice-based ORS are now preferred over glucose-based ORS, and have been included in WHO (World Health Organization) programs (Gore *et al*., 1992). Rice is the least allergic food and is recommended for people afflicted with the irritable bowel syndrome. Colored rices (red and black) have been extensively studied and their anthocyanins or colored pigments and flavonoids are associated with antioxidant properties (Zhang *et al*., 2005).Red and black rices are considered more nutritious, have been found to be rich in iron (Fe), zinc (Zn), and minerals, and possess antioxidant properties. These rices reduced atherosclerotic plaque by 50% more than white rice in rabbits (Ling *et al*., 2001). The parboiled red rices of Sri Lanka have lower glycemic index than white rices, and have been recommended for diabetics (Hettiarachchi *et al*., 2001) [18]. The antioxidant and scavenging activity of red ice is higher than that of black and white rices. Clinical trials conducted in USA have concluded that red rice yeast reduces cholesterol and total triglyceride,

providing a novel food-based approach to lowering cholesterol (Herber *et al*., 1999) [17].

Though rice contains high levels of complex carbohydrates and is categorized as a high glycemic index food along with bread and potato, many traditional varieties have been reported to have a low glycemic index (Rhoades, 2003) [30]. Basmati rice is one of them. It is now known that phytate in cereals ties with dietary Fe and keeps the human body from absorbing it. Basmati rice makes a metallothione in-like protein that is rich in cystine that aids in iron absorption; this gene is being used in the development of Fe-rich rice through biotechnology (Chaudhary and Tran, 2001) [6].

During these studies, it was found that basmati has medicinal value too. It has a low glycemic index, is high in Fe and Zn, and helps in the bio-availability (adsorption) of Fe. In the race to increase production, we have neglected so far, the rich treasure and heritage of small- and medium-grain scented rices that may possess equally good qualities in terms of their cooking, nutrition, and mineral content. Rice meets most of the requirements of a good and healthy food. Rice is the only cereal that is eaten as a whole grain, which according to Ayurvedic texts is more easily digestible than flour.

Recent studies on chemical composition of medicinal rice

Medicinal rice can be termed to those varieties which have some additional health benefits then the common varieties. Varieties, land races, cultivars, wild relatives known by locals for medicinal properties are tested out in different part of the world for their chemical composition and medicinal properties.

Njavara is an important medicinal rice variety of Kerala, India, widely used in Ayurveda as a 'health food' and in the treatment of rheumatoid arthritis, paralysis, neurodegenerative diseases and in rejuvenation therapy. Phytochemical investigations and spectroscopic studies of the diethyl ether fraction of methanolic extract of Njavara Black rice bran gave three important compounds namely, tricin and two rare flavonolignanstricin 4′-O-(erythro-β-guaiacylglyceryl) ether and tricin 4-O-(threo-β-guaiacylglyceryl) ether. The EC values of these compounds in DPPH system were 90.39, 352.04 and 208.1 µg/ml, respectively. Quantification of the compounds by HPLC in Njavara Black and staple, non-medicinal rice varieties Sujatha and Palakkadan Matta showed that tricin is present 39.64 and 16.12 fold higher in Njavara, compared to Sujaths and Palakkadan Matta, respectively. This is the first report on the occurrence of tricin at significantly higher levels in Njavara and occurrence of the two flavonolignans in *Oryza sativa* species.

Comparisons of physiochemical, total phenol, flavanoid content and functional properties in six cultivars of aromatic rice in Bangladesh in which various aromatic rice varieties such as Kalizira, Begun Bichi, BRRI dhan-34, BRRI dhan-37, BRRI dhan- 50, PhilipineKatari were analyzed for physiochemical, total phenol, flavonoid contents and functional properties. All aromatic rice varieties had moisture contents (11.25 to 15.13%), protein (3.23 to 6.21%), fat (0.68 to 1.45%) and ash (0.88 to 1.46%). The maximum amount of amylose and starch content were obtained in BRRI dhan-37 and BRRI dhan-50 (23.01 and 72.606%, respectively). Total phenolic content was higher in BRRI-37 (474 mg/100 g); whereas, lower value was observed in BRRI dhan-34 (268.67 mg/100 g) variety. Both Philipine Katari and kalizira variety possessed highest level of flavonoid content among all rice varieties. Highest water absorption index value was found in BRRI dhan-37 and lowest in Begun Bichi variety. On the other hand, water soluble index value was varied by 1.32 to 2.12% in all aromatic rice varieties. Therefore, the study indicates that aromatic rice could be used as functional food ingredients as well as sources of natural phytochemicals. (Asaduzzaman *et. al.*, 2013) [2]

Genetically-engineered'Bio-Fortified' Rice

Modern rice seeds contributed to the current problem of micronutrient malnutrition. Most of the commercially cultivated rice varieties, predominantly 'modern' varieties, are deficient in iron and zinc. Rice plant breeders, during the Green Revolution and afterwards, did not select for micronutrient-rich rice when they were developing new high-yielding varieties. With the advent of genetic engineering, scientists have sought to introduce nutrient-enhancing genes into rice. For example, genes from maize and a common soil micro-organism that produces beta carotene were incorporated into rice to produce 'Golden Rice' (also known as Vitamin A rice or beta carotene rice). Golden Rice was developed by Professors Beyer and Portykus along with Syngenta, one of the world's largest agrochemical and seed companies.

There is also ongoing research to fortify rice with iron through genetic engineering. This is accomplished by inserting two plant genes into existing rice varieties, resulting in grains with six times more iron than typical milled rice. Iron in rice is mostly found in the bran, which is lost in milling. Researchers have recently succeeded in folate (Vitamin B9) bio-fortification ofrice61 and research is underway on rice bio-fortified with zinc. Research is now underway to turn rice into a pharmaceutical product (pharma rice). Rice porridge has been traditionally used in rural communities to address dehydration resulting from diarrhea and the World Health Organization has been using rice-based oral rehydration salts (ORS).

Need to Conserve Traditional Rice Varieties

Traditional rice varieties must be saved from being lost as they are good sources of nutrients and many possess medicinal properties as well. Planting and consuming traditional rice varieties, and researching and promoting traditional knowledge on the value of local seeds to human health and nutrition will help arrest the continued loss of traditional rice varieties. Let us support farmer groups conserving and developing traditional rice varieties by patronizing their products and promoting the positive aspects of having diverse rice in our diets. Intellectual property rights (IPRs), which provide monopolistic private rights over seeds, should be replaced with a system that upholds farmers' rights to save, use, develop and exchange seeds freely. Farmers have already provided all their seeds to the world for free. The new varieties they continue to develop are also provided for free. We must take action to ensure that seeds are not subject to IPRs. Corporate control over seeds is among the biggest threats to the very biodiversity that ensures the safety, health, nutrition and sustainability of the planet and its people. Farmers' traditional seed exchange systems and local innovation processes were the reasons we could enjoy diversity in our food, thus we must ensure that these systems and pathways continue.

Conclusion

India is home to a number of rice varieties that have medicinal properties and that fit the description of a health food in terms of modern as well as olden concepts. There is

an urgent need to conserve these varieties that are fast disappearing under the pressure of high-yielding varieties and other cash crops. The need of the day is to aggressively market these varieties and promote them through greater public awareness about their importance, especially among the younger generation. Clinical validation of their medicinal value is necessary in order to establish a niche in the global market (the way China sells red rice yeast the world over). The promotion and conservation of this national heritage as a health food is critical in order to stem the onslaught of lifestyle-related diseases.

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