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Review

Rice and diabetes-a comprehensive review

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Abstract

Rice is a staple food of most Asian diets and a major contributor to high carbohydrate load. Even though a number of factors are associated with the progression and development of diabetes mellitus. The consumption of white rice is sought to be one of the common factors for diabetes mellitus due to its high glycemic index (GI). The prevalence of diabetes in Asian countries is higher, particularly in India and China. Since diabetes imposes a serious threat to an individual's health and causes a societal economic burden, research on its management and prevention is now one of the most sought areas of interest. The present review is focused on the importance of rice in India and includes ways in which increased consumption of white rice causes diabetes. Since dietary knowledge and practices are crucial in the management of the disease, the present review focuses on the effect of indigenous rice varieties of South India other than the most commonly consumed white rice in the management of diabetes.

Keywords: Indigenous rice varieties, White rice, South India, Diabetes mellitus.

Introduction

Rice (*Oryza sativa* L.) is the second most noteworthy staple food crop [1] after wheat around the world. It is produced in more than 100 nations, eaten by more than two billion individuals every day and is the primary protein hotspot for millions. It is a staple food for Asian, Latin American, Caribbean, and African populations [2]. About 90% of the rice is delivered and expanded in Asia [3], where it is something other than a staple eating regimen. India is a major producer and consumer of rice and a hot spot of rice biodiversity [4]. Some studies revealed beneficiary health effects of rice and its products [5]. Some rice pigment can inhibit atherosclerotic plaque formation since it has antioxidant or anti-inflammatory effects [6]. Rice is also one of the foods deemed to be a possible food carrier for micronutrient fortification due to its daily use. Many studies tried to add iron and zinc to rice in order to balance the nutritional problems, especially micronutrient deficiencies. Research in children and their caregivers from Bangladesh found that rice was the key source of zinc consumption, supplying children with 49% of dietary zinc and women with 69% [7].

Among the rice varieties, white rice is the most commonly consumed one in the country. The traits like easier availability and cost-effective make this type of variety a preferable one when compared with other varieties. But higher consumption of white rice has been found to be associated with the increased risk of type 2 diabetes in Asian populations [8]. These are considered as high glycemic foods and it gets easily absorbed in the blood which simultaneously increases the postprandial blood glucose level and insulin

demand leading to diabetes [9]. Unlike white polished rice, brown rice slowly releases sugars, which in turn helps to stabilize blood sugar sustainably. This trait makes it a better option for people who are suffering from diabetes mellitus [10]. However, earlier studies have shown a link between white rice consumption and type 2 diabetes risk. Dietary fibers enhance carbohydrate absorption by providing a food ring, obstructing the action of hydrolytic enzymes in the small intestine on food, and the viscosity of food in the intestine [11]. This plays a crucial role in reducing food glycemic index (GI), thus avoiding the risk of type 2 diabetes. Proanthocyanidins present in red rice provides protection against type 2 diabetes [12]. Likewise, it is reported that anthocyanin found in black rice has a hypoglycemic effect [13]. On the other hand, a number of indigenous rice varieties with higher nutritional and therapeutic properties are still cultivated in many parts of India. But due to a lack of research knowledge on the indigenous rice varieties, their therapeutic potentials are still unexplored and the people are not aware of it. Hence this review is intended to bring out the unexplored potential of Indigenous rice varieties of South India in the management of diabetes mellitus.

Medicinal uses of rice

India has an abundance of restorative plants, the majority of which have customarily been utilized for ages in Ayurvedic, Unani therapeutic frameworks, and by inborn healers [14]. It is unmistakably referenced in antiquated Indian writing that each plant on this planet is useful to people, creatures, and different plants [15]. The therapeutic qualities for rice were depicted in Ayurveda: rice is viewed a harsh, oleaginous, tonic for Spanish fly, swelling, diuretic, and helpful in biliousness. Rice is generally developed in Chhattisgarh and is known as "India's rice bowl". Rice is thought to have restorative properties by a few. In spite of the fact that this isn't experimentally demonstrated successful, it has been utilized for therapeutic purposes in numerous nations. The traditional healers utilize different pieces of restorative rice to treat both normal and muddled sicknesses. The therapeutic rice assortment "Laicha" was so named for forestalling "Laicha" sickness (skin contamination) due to its one-of-a-kind property. It was seen during the study that the more youthful age is less mindful of these therapeutic rice varieties than the more seasoned ages, so documentation of this important data about the restorative estimations of conventional rice varieties in the area is unequivocally required. The popular restorative rice Alcha, Laicha, Baissour, Maharaji, Jhilli, Kanthi Banko, Udan Pakheru, Ramkeli, Shyam Lal, Tenduphool and so on were keep on being developed and utilized in customary recuperating [16].

Polished white rice – Hello diabetes

Cleaned rice or polished white rice, which for the most part comprises of starch, is created through a progression of motorized procedures including hulling and processing [17] and is the prevalent sort of rice expended around the world [18]. Albeit a specific white rice assortment's glycaemic record esteem relies upon the level of preparing, cooking time, and amylose content, the white rice glycaemic file esteems are higher on normal than those of entire grains. For instance, in a past meta-butt-centric, the mean glycaemic file esteems were 64 (SD 7) for white rice, 55 (5) for earthy colored rice, 41 (3) for entire wheat and 25 (1) for grain. In addition, white rice is the primary contributor to dietary glycaemic load for populations that consume rice as a staple food [19, 20].

White rice increase causes diabetes

With the advancement of grain processing technology, refined grains are produced in higher amounts through a series of processes such as milling and hulling. The outer bran and the germ portion of the brown rice get removed by the refining process and it produces white rice. The white rice thus formed is a polished one and is devoid of essential micro-nutrients and consist primarily of starch endosperm [21] and contains about five times less fiber than the brown rice.

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In general, the refined grains are found with low fiber content and are rich in carbohydrates [22]. These are considered as high glycaemic foods and it gets easily absorbed which simultaneously increases the postprandial blood glucose level and insulin demand leading to diabetes [23]. In contrast, the whole-grain foods were reported to improve insulin sensitivity thereby reducing the risk of type 2 diabetes [24–26]. Among the rice varieties found worldwide, polished rice or white rice is the most predominant variety of rice consumed by the world's population. The people of South India were consuming this polished white rice and nearly half of the daily energy intake from this variety is greater than 75% which enriches the calorific value but also leads to type 2 diabetes [27].

A high carbohydrate diet is generally assumed to be a major factor in the diabetes disorder besides obesity, a high fat intake and a sedentary lifestyle. Notwithstanding weight, high-fat admission, and an inactive way of life, a high starch diet is for the most part dared to be the main consideration in the diabetes disorder [28]. Since rice is starch with a high glycemic file, the relationship of a rice-based eating regimen with a higher rate and commonness of type 2 diabetes isn't unexpected [29]. Nevertheless, the glycemic index of rice may not be the primary or sole cause of associating a high intake of white rice with diabetes. An alternative theory is that rice has a high content of inorganic arsenic and is diabetogenic with a high intake of food [30].

A meta-investigation has demonstrated a higher utilization of white rice worldwide to be related to an altogether higher danger of type 2 diabetes especially in Asian populations [8]. The risk increased by 55% (CI 1.20–2.01) as compared with the highest to the lowest level of white rice consumption in Asian populations, While hazards in Western populations expanded by 12% (CI 0.94–1.33 p=0.038). By and large, the overall danger of type 2 diabetes with every day by day serving of rice expanded by 11% (CI 1.08–1.14) [8]. White rice consumption in the United States is still relatively small but since the 1930s the intake has increased to the average intake of 20.5 lbs each year. Three imminent American grown-up considers (two Nurses Health Studies and the Health Professional Follow-up Study) indicated that expanded white rice utilization is associated with expanded diabetes rate. Across these trials, a white rice consumption of more than five portions per month compared to less than one serving per month was correlated with a statistically significant 17% increase across diabetes incidence (CI 1.02–1.36) [21]. It is also revealed that intake of white rice was related to the higher risk of diabetes mellitus type II than brown rice from their studies. The planned examination in Japan demonstrated that increased white rice consumption is related to an expanded danger of type II diabetes among ladies. The odds ratio for the maximum rice consumption (762±103 g/dl) relative to the lowest quartile (226± 00 g/dl) was 1.65 [19].

On account of its tastefulness, white rice is the most generally devoured sort of rice around the world. Through the milling procedure, earthy colored rice's external wheat and germ divides are isolated, leaving a dull finished result (white rice) with low fiber, nutrient, and mineral substances [31]. Therefore, white rice has greater carbohydrate content and a high glycemic index (64%), which may account for the increased risk of type 2 diabetes [20, 32]. Salmeron et al. [33] have shown in large epidemiological studies that diets with a high glycemic load and low cereal fiber content are associated with an increased risk of developing diabetes in both men and women.

Arsenic and rice

As of late, the Food and Drug Administration (FDA) discharged admonitions that rice contains undesirable arsenic levels, and suggested youngsters devour just rice pasta or rice oat once at regular intervals [34]. The inorganic arsenic introduction has additionally been demonstrated to be related to an expanded danger of developing type 2 diabetes [35]. Those with type 2 diabetes had a 26% more significant level of urinary arsenic than non-diabetic subjects in the 2003–2004 National Health and Nutrition Examination Study (NHANES). In Taiwanese towns that are presented to elevated levels of encompassing arsenic, the pervasiveness of diabetes in those matured somewhere in the range of 65 and 74 years who have long haul presentation was 5.5

occasions higher (CI 2.2–13.5) than in those towns who have low arsenic introduction [36].

A potential system by which high arsenic presentation brings about the improvement of diabetes through impedance with PKB/Akt-subordinate GLUT4 transporter preparation bringing about insulin opposition [37]. Introduction to significant levels of arsenic can likewise build the glitch of beta-cells. Significant levels of arsenic add to raised degrees of two cytokines that are insulin safe (tumor putrefaction factor-alpha and interleukin-6). Insulin resistance is also increased by inhibition of proliferative-activated receptor gamma (PPAR gamma), a nuclear hormone receptor that increases insulin sensitivity. High levels of arsenic also induce oxidative stress which, in addition to increasing insulin resistance, induces beta-cell dysfunction by activating the nuclear factor-kappa B. Nuclear factor-kappa B is also known as NF-kappa B. In addition, superoxide can induce amyloid formation in the pancreas by interacting with uncoupling protein 2 (UCP2), which will ultimately kill the insulin-secreting beta-cells [38].

Henceforth, the relationship of a high admission of white rice with diabetes could be because of exorbitant admission of a high glycemic record sugar or potentially high arsenic consumption.

Glycaemic index and diabetes

Nourishments with a high GI have been related to the expanded danger of type 2 diabetes, since they are immediately processed and can cause exceptional ascents in glucose levels. GI is a generally acknowledged marker of the effect of nourishments containing sugars on human well-being like rice [39]. Glycemic load (GL) in any case is an augmentation of the GI definition. The GL esteem fuses the measure of rice in a serving to all the more likely evaluate the effect of an eating routine on the postprandial reaction to glucose [40]. GI- based weight control plans, including rice, are isolated into three classes: low GI (55 or less), medium GI (56–69), and high GI (70 or more prominent). Furthermore, the weight control plans are evaluated as low GL (10 or less), medium GL (11–19), and high GL (at least 20), in light of GL.

Glycemic file quantifies the rating in singular subjects of the glycemic limit of the different suppliers. In patients with insulin-subordinate diabetes (type I), and non-insulin - subordinate diabetes (type II), low-GI counts calories bring about moderate upgrades in by and large blood glucose control. The system can lessen insulin emission through the capacity of low-GI diets and diminishing blood lipid focuses in patients with hypertriglyceride [40]. The medium and high glycemic (GL) rice that Bangladesh expends the most was tried for the GL and GI. The high GL rice has a significantly higher GI than the medium one [41]. Several studies have revealed that a high GI diet may have adverse effects on human health such as the risk increase of chronic diseases such as cardiovascular disease (CVD), type II diabetes, and obesity. As a consequence, it is suggested to consume rice with low GI [11]. GL relies upon the quantity of the serving size; henceforth, a little segment of this rice and an expanded quantity of vegetables or other low-sugar dishes can adjust the general glycemic impact of the entire eating regimen and give satiety also. Because of this atherogenic function of insulin, regulation of patients' blood glucose and maintaining their insulin level as small as possible is beneficial [41].

South India region

South India is the locale incorporating the peninsular Indian district confronting south of the Vindhya Range. The northern boundaries of the region are marked by the rivers Narmada and Mahanadi. The Southern region is surrounded by the Bay of Bengal in the east, the Indian Ocean in the south, and The Arabian Ocean on its west. The Western Ghats and the Eastern Ghats and an eminent piece of South India's topography are level heartland region. South India's everlasting streams that structure the area's significant water sources are Tungabhadra, Kaveri, Krishna, and Godavari.

The four states that make-up India's southern part are Andhra Pradesh, Karnataka,

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Kerala, and Tamil Nadu, and the Lakshadweep and Pondicherry Union Territory including Yaman, Mahe, and Karaikal. At this current area's southernmost tip is Kanyakumari, one of the Hindus' well known strict places of worship. The popularly spoken languages in South India are the Dravidian languages, but some communities like the Konkani speak other than Dravidian languages. The languages mainly spoken in south India are Tamil, Kannada, Telugu, Malayalam, Konkani, and Tulu.

With a tropical climate, south India is famous for its flora and fauna. South India has flourishing evergreen vegetation. The Western Ghats are full of moist deciduous forests, tropical dry forests, dry deciduous forests, and thorny scrub forests. It is regular in the focal level of Deccan, the high elevation rainforests on the south Western Ghats; the soggy backwoods on the Malabar Coast give a beautiful perspective on South India's biodiversity.

Effect of the indigenous rice varieties of south India in management of diabetes

In India, there are many traditional rice varieties are grown and consumed in almost all parts of the country. The indigenous rice varieties were grown from the Chakra Samihita period i.e. 400–700 BC for their medicinal values [42]. The indigenous varieties of rice and millets are resistant to drought, salinity, and floods. For instance, Eastern India's Dharical, Dular, and Tilak Kacheri are adaptable to various topologies, climates, and soils [43].

Traditional rice cultivars have a high nutritional value compared to hybrid rice varieties [44]. They are a good source of minerals and vitamins such as niacin, thiamine, magnesium, riboflavin, vitamin D, calcium, and have higher fiber. In addition, these cultivars have many health benefits, such as decreasing the risk of developing type II diabetes, obesity, and cardiovascular disorders by minimizing the glycemic and insulin response [45]. In examination with maize, wheat, and potatoes, crude, long-grain white rice is a decent wellspring of starches, calcium, iron, thiamine, pantothenic corrosive, folate, and nutrient E. It needs nutrient C, nutrient A, beta carotene, lutein, and zeaxanthin. It is fundamentally low in dietary fiber, as well.

Chhattisgarh's Laicha rice and Kerala's 'Navara' rice are the therapeutic rice varieties that clearly had for some time been treating sicknesses, for example, incessant gastritis and peptic ulcer. Tamil Nadu's 'Bhat moori' which fixes weakness and upgrades ladies' blood dissemination after labor, contains folic corrosive that acclimatizes dietary iron. West Bengal's Parmai-sal has extraordinary healthful quality properties; Orissa's Kabiraj-sal is taken care of to convalesce patients to quicken recuperation.

Some customary varieties of South Indian rice, for example, Kavuni have potential against microbial action. Kaivara Samba diminishes glucose. For its medical advantages, Kuruvi Kar is impervious to dry spells and devoured by local people. Poongar is devoured by ladies after adolescence and is accepted to forestall regenerative framework-related infirmities. Kattu Yanam brings down blood glucose levels and invigorates also. Koliyal is broadly eaten as a puttu, a dish of claims to fame. Maapillai Samba has a hypocholesterolemic impact and movement against disease, and furthermore improves men's richness. Dark Kavuni is impervious to the dry season and is well known for its medical advantages among local people (Figure 1). The details of the indigenous rice varieties are discussed below:

Black Kavuni rice

The Kavuni rice grains have been cultivated under limited areas of Tamil Nadu, India. Since 400 BC, the black Kavuni rice has been utilized as the best nutrition supplement and used up for the treatment of gastritis and peptic ulcers and management of diabetes. Besides this, it also enhances blood circulation. As it was enriched with nutrients, consumption of this rice strengthens the body. The grains of the Kavuni rice was black in color and were enriched with minerals like zinc, copper, sodium, potassium, and manganese. It contains reduced levels of total reduced sugars, increased protein content, low-fat content and increased concentrations

of phenolic acids, carotenoids, and flavonoids. Besides its nutritional enrichment, it was known for its anti-diabetic properties because of its inherent ability to inhibit α- glucosidase and α-amylase enzymes which in turn hinders the processing of carbohydrates and reduces the rate of the assimilation process. These events simultaneously decrease the postprandial blood glucose level that was usually calculated after meal consumption [46]. In addition to this, [47] research aimed at revealing the anti-diabetic properties of Kavuni rice in comparison with other popularly consumed white rice varieties of Tamil Nadu such as CO 50 and IR64. Through their studies, it was revealed that Kavuni rice possessed notable nutritional and therapeutic potential like preventing diabetic complications by inhibiting the enzymes such as α-amylase and α-glucosidase that plays a prominent role in the development of diabetes. The product formulated using this traditional rice variety was found to have more nutritional values than the non-pigmented rice varieties. Kavuni rice can be used as a complete solution for sustainable health and best-suited rice for diabetics [48].

Nijavara rice

Nijavara, an indigenous variety of Kerala is a unique grain plant in the Oryza group. It is also referred to as Navara rice. This rice variety has a special status being predominant in medicinal values. It has been under cultivation in the state for about 2500 years. The Nijavara rice varieties have been extensively used in the Panchakarma treatment. Deepa et al. [49] researched the nutritional and physicochemical properties of Nijavara rice with a view of finding its therapeutic applications and concluded that the dehusked Nijavara rice was enriched with a relatively higher protein, minerals, vitamins, and fiber contents when compared with two non-medicinal rice varieties such as Jyothi and IR64 through in vitro studies. Deepa et al [50] also studied the genetic variations and few physicochemical properties of this traditional rice variety and found out distinct unadulterated gene pool of the Kavuni rice through genetic analysis. Further, through molecular markers, it was found out that the rice was enriched with higher protein content and possessed higher pasting and thermal properties. Further, Nijavara rice can be used in the formulation of plant-based pharmaceutical products [51].

Rajamudi rice

Karnataka is blessed with a rich heritage of rice varieties. Rajamudi is a red rice variety indigenous to Mysore, Karnataka. It has been said that the farmers who could not pay their taxes to the king were asked to pay some quantities of this Rajamudi rice to the king as a lieu of their taxes and hence the name Rajamudi. This rice variety was famous during ancient days, but with the emergence and populance of white rice, this red rice variety was pushed into oblivion. It has good dietary fiber when compared with polished white rice and is enriched with antioxidants and zinc. The antioxidants prevent the body from free radicals. Zinc improves immunity and speeds ups the recovery and healing process. Since it has a low glycemic value, it was well suited for diabetics [52].

Mappillai Samba rice

It is one of the most popular varieties of rice grown in Tamil Nadu, India. It is well suited for organic farming and it doesn't require any kinds of fertilizers and manure. It is rich in medicinal values. The name Mappillai was bearded after a famous tradition, where a bridegroom (Mappillai in the Tamil language) is asked to lift a heavy rock with a view to express his valiance. In order to gain and strengthen energy to perform such actions, the bridegroom is given this rice in cooked form. To date, this tradition is being followed in many parts of Tamil Nadu. This rice when consumed slows down the release of glucose into the blood and is hence best suited for diabetic patients. It contains higher vitamin, flavonoid, and anthocyanin content [53]. Krishnanunni et al [54] researched to analyze the chemical composition and volatiles present in the traditional rice varieties of Tamil Nadu such as Mappillai Samba

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and Karungkuravai. Through their studies, it was revealed that a number of phytosterols were found in both rice varieties. Medically prominent molecules like Curlone and 1-4-benzodiazepine-2-one were found in both rice varieties. Further, the rice varieties were supplemented with phenolic compounds and antioxidant capacities.

Kattu Yanam rice

Kattu Yanam is one popular rice variety in Tamil Nadu. It is a red rice variety and is mostly grown in the Dharmapuri district of the state. It is also best suited for organic farming, once the seeding process is done; Farmers will go only for harvest. The height of the crop plant is very high, even elephants can hide inside the crop cultivated area and hence the name Kattu Yanam. The duration required for yielding the crop is 125–130 days. This rice variety is both drought and salt-water tolerant. It is enriched with vitamins and minerals. It lowers the glucose levels in the blood [55] and is hence called as an enemy of diabetes. This unpolished rice variety decreases cholesterol levels and improves heart health. It contains high fiber content and thereby enhances digestion.

Kichili samba rice

The Kichili samba rice also known as Kichadi samba is the mother DNA of all the popular IR varieties of rice. Its name was derived from its natural fragrance like citrus fruit. The rice is very small in size and is grown organically. The crop grows up to a height of 3 feet and takes 135–140 days for its yield. It is mostly cultivated in the Kancheepuram, Sirkazhi, and Thiruvannamalai districts of Tamil Nadu. Ahttur Kichili samba, Arcot Kichili samba, and Ottu Kichili samba are some of the variants of this rice variety. In the

Figure 1: Indigenous rice varieties of South India used in the management of diabetes. A. Black Kavuni rice of Tamil Nadu, B. Navara rice of Kerala, C. Rajamudi rice of Karnataka, D. Maapillai Samba rice of Tamil Nadu, E. Kattu Yanam rice of Tamil Nadu and F. Kichili samba rice of Tamil Nadu.

ancient days, this rice was consumed only by royal families. It is best known for its anti-diabetic properties since it has a relatively lower glycemic value of 50 [56].

Thuyamalli rice

The Tamil name of the rice refers to pure jasmine because it resembles the bud of the jasmine flower in its appearance. It is an indigenous rice variety of Tamil Nadu and is mostly cultivated in the Salem district of Tamil Nadu. It is a pear-colored, milled rice variety. It does not require much pesticide. It prevents diabetes completely. It also prevents the internal organs from quick aging. Thuyamalli possessed notable nutritional and cooking properties.

Conclusion

The measures discussed above were initiated to revive the information on indigenous rice varieties of South India with anti-diabetic efficiencies. In this study, it is concluded that a high intake of white rice is associated with a high incidence and prevalence of diabetes. While this could be ascribed to some extent to the high substance of starches in the glycemic file, it could likewise be inferable from the significant level of arsenic in rice. All traditional systems of medicine follow the dictum "Food is medicine and medicine is Food". The traditional Siddha describes good food as alchemy, which helps to restore health and rejuvenate the body and leads to an exalted life. In such context, the indigenous rice varieties apart from their anti-diabetic and other therapeutic properties are highly nutritious that aids in the well-being of the individuals.

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Conflict of Interest

Nil.

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