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Glucose index and chemical composition of rice cultivars and their effect on type 2 mellitus diabetes

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Abstract: Rice is the staple food and energy source for half of the world's population; thus, it has great nutrition and, at the same time, health effects. Rice is generally considered a food with a high glycemic index (GI). However, this depends on the cultivar, textural and processing factors. As a significant contributor to the population's increased glycemic load when rice is consumed, there is growing concern that the high prevalence of insulin resistance results from consuming large amounts of rice. Therefore, devising ways and means to reduce the effect of rice on blood sugar is imperative. This review compiles studies examining the glucose index of rice products. Tables of the chemical composition of rice are also included. Rice elicits a relatively large glycemic response and is associated with exacerbating glucose intolerance. This contributes to an increase in the glucose load (GL) of diets in countries where it is the main ingredient due to the large amount eaten and the increase in its population index in these countries where an increase in diabetes rates has been observed.

Keywords: Brown rice; basmati rice; glucose index; glucose load; amylose; amber rice; insulin; diabetes; cortisol; blood glucose.

Firstly: Introduction

The cornerstone of diabetes prevention and management, nutritional interventions primarily aim to maintain a low and stable postprandial blood glucose concentration. Based on the glycemic response, the glycemic index (GI) indicates the potential for raising blood glucose from carbohydrate-containing foods. Studies show that regular consumption of a high glycemic index is associated with an increased risk of developing type 2 diabetes. Evidence shows that low-glycemic index diets reduce the incidence of diabetes, hyperlipidemia, and cardiovascular disease. Although simple carbohydrates such as glucose and maltose have historically been the largest inducers of hyperglycemia, recent data conclusively show that complex carbohydrates, including that, starches can produce equal or even more significant amounts of glucose in the blood (Kaur et al., 2015).

The sugar level in the blood rises after eating, and although its rise in the blood provides the body with energy, it can cause damage to somebody's systems and organ functions. When blood sugar rises very quickly, it also tends to drop quickly. This rise and fall change the body's secretion of adrenaline, insulin, and cortisol (stress hormone) hormones. The combined effect of these hormones makes a person feel tired and more stressed while the body converts more energy into fat, increases hunger and inflammation, and increases pain and the risk of chronic diseases such as heart disease.

The glucose index of a food is the result of an action of digestion and absorption of food, as it leads to the emergence of a change in the level of glucose in the blood. It is called (Glycemic index) and is expressed in the measured area under the blood glucose response curve after fasting or the food under test, relative to the measured area under the response curve Blood glucose for white bread or glucose (Raben, 2002). The value of this indicator appears for each food eaten, as it can be classified into three groups, which are foods with a high glucose index (GI ≥ 70%), foods with a low glucose index (GI ≥ 55%) and foods with a medium glucose index (GI = 55-69). %) (Rasmussen et al.,1993; Riccardi, 2003).

The research aims to know the glucose index, glucose load, and chemical composition of rice varieties and their effect on diabetes.

Secondly: Rice

The first Rice (*Oryza sativa* L.) belongs to the Poaceae family. The original home of rice is not known precisely, but it is likely to be from East Asia. Its cultivation began in China in 2000 BC, and it was transferred

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to Europe and Africa. Other studies suggest that the origin of rice was cultivated. It was widely distributed in South and Southeast Asia river valleys 10,000 years ago and is likely to have originated in India. The domestication of rice in India is mainly attributed to the Indus Valley Civilization (1500-3000) BC (Gnanamanickam, 2009). It is currently considered the staple food for about 3.5 billion people worldwide (Zewdu, 2020). With an estimated global annual production of around 480 million tonnes, an average yield of 4.4 tonnes per hectare, and a harvested area of about 160 million hectares, rice is one of the world's leading food crops and is also estimated to produce more food energy per hectare than any other cereal. It provides 20% of the world's dietary energy supply and is the dominant staple food for 17 countries in Asia, 9 countries in North and South America, and 8 countries in Africa (Sahebi et al., 2018; Kim et al., 2020).
Rice in Iraq is one of the most important summer crops, ranked third after wheat and barley, occupying 5-6% of it. Iraq's cultivated area for 2021 was estimated at about 384,926 hectares, producing 422,463 tons, with an average yield of 1097.5 tons per hectare (MOP, 2021). The governorates of Najaf, Diwaniyah, and Muthanna represent Iraq's first center for rice cultivation and production. Statistics indicate that the cultivated area in these three provinces constitutes approximately 70% of the total cultivated area in Iraq. The rice-growing season begins in June and July and ends in October and November (et al., 2021 Musa).
Rice constitutes an essential source of carbohydrates, especially starch, mainly found in the endosperm cells of mature brown rice and accounts for about 90% of the dry weight of milled rice (Kaur et al., 2021). The physical properties of rice cooking depend on the starch and its interactions with other components such as fats, proteins, and water (Dong et al., 2022). Since the rice crop is closely related to the carbohydrates produced during photosynthesis, using light energy is key to rice production. Although rice plants show an increase in light-capturing capacity under shading stress through an increase in chlorophyll content, there is a decrease in the assimilation rate. Photosynthesis, saturation radiation, and electron transfer rate, along with the limited supply of electrons for photosynthesis metabolism (Gautam et al., 2019; Wang et al.,2015), so under shading stress, the photosynthetic production of rice may be limited, thus limiting plant growth and development (Liang et al., 2017).
Rice depends not only on photosynthesis after the formation stage but also on the replenishment of stored carbohydrates before heading to the vegetative organs, especially in the stem plus sheath (SPS) (Stella et al., 2016; Fu et al., 2011), these recycled carbohydrates Packaged, also known as nonstructural carbohydrates (NSC), are soluble sugars and starches that play a significant role in the composition of the rice yield (Panda and Sarkar, 2014). Thousands of rice varieties are grown all over the world, and India is home to 6,000 varieties at present, where previously India had more than 110,000 varieties of rice until 1970, which were lost during the green revolution with its focus on monocultures and hybrid crops (Rathna et al., 2019). From 40,000 varieties of rice grown worldwide, only two significant cultivars are widely cultivated: Asian rice (*Oryza sativa*) and African rice (*Oryza glaberrima*) (Charara, 2021).

Third: Rice types

Crop genotypes generally play an important role in production through higher production and resistance against insect pests and diseases under different climatic conditions because it is a staple food for most countries of the world, from which thousands of varieties of different quality have been derived, including Iraqi amber rice, which is essential types of rice in Iraq, which is grown significantly in the southern region, and the reason for its importance is due to its intense whiteness, distinctive smell, high protein percentage, and large seed size. It was given this name because of its smell, similar to amber. Growing it in clay soil and watering it with Euphrates water is preferable. Its cultivation season is in May, and it continues to grow for six months when the harvest season is in mid-October (Chakravarthi and Naravaneni, 2006). Studies indicated that rice cultivation in Iraq declined in the central and southern regions due to water scarcity and lack of rain. The product became insufficient for the interior, which demanded its abundance. The research showed that the Iraqis were among the first people to cultivate rice before the Indians and Asians; some researchers believe that “rice” has historical dimensions and initially trace it back to the Sumerian era (Kosambi, 2022).
Wasan et al. (2022) indicated another important variety of rice: brown rice. Thailand, followed by Vietnam, India, Indonesia, the Philippines, Iran, and Nigeria, are the most productive countries, and it is one of the nutritious carbohydrates and contains low calories and a high amount of fiber, in addition to "It is a good source of magnesium, phosphorous, selenium, thiamine, niacin, vitamin B6 and an excellent source of

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manganese. It retains the bran layer, and this is because the vitamins are confined to the rice husk, as the presence of the bran is evidence of the presence of anthocyanins that inhibit reductase and anti-diabetic activities, which helps to stabilize blood sugar sustainably. This feature makes it a better choice for people with diabetes. Diabetes mellitus (Yawadio et al., 2007). Brown rice is associated with a lower risk of cancer, and studies have also indicated that using whole grains such as brown rice is associated with lower levels of colon cancer. This may be related to its high fiber content. As fiber binds to carcinogens and toxins, it helps to eliminate them from the body and prevents them from sticking to cells in the colon (Chen et al., 2016; Size, 2019).

Long-grained Basmati rice is widely produced in India, as it produces more than 60% of the total production of basmati rice in the state of Haryana in India. It is also grown in Pakistan and has achieved high productivity. It is a good source of carbohydrates, calcium, iron, thiamine, pantothenic acid, folic acid and vitamin. The premium varieties of Basmati rice are high-quality rice with high prices in national and international trade. However, basmati rice's yield per unit area is meager due to its tall vegetation habit and late maturity (Singh et al., 2018).

Fourth: The difference between types of rice, especially in terms of amylose and amylopectin

The ratio of amylose to amylopectin affects processing properties and food quality. Amylose is directly related to the hardness, whiteness and dullness of cooked rice, its expansion volume and water absorption during cooking.

Although the reported glucose index (GI) of different types of rice is not equal, most types of rice are classified as low or medium (GI) foods, but this is affected by the cooking time and type of rice. At the same time, many studies have examined the link between high carbohydrate intake and the risk of chronic diseases such as obesity, type 2 diabetes, and cardiovascular disease; relatively little has investigated the role of rice specifically, particularly in Western populations. As for the Asian population, who consider rice a staple food, higher consumption of white rice has been associated with a higher risk of diabetes and metabolic syndrome, and some studies in the United States have linked regular consumption of white rice with a risk of developing type 2 diabetes while eating brown rice reduces the incidence. However, future studies should consider potential differences. White rice cultivars differ in amylose content and the effect of processing methods (Schenker, 2012).

Typically, rice is affected by the ratio of amylose to amylopectin in cereals and studies by Kumar et al. (2020) showed that rice with a higher amylose content (Doongara, 28% amylose) gave a significantly lower glycemic index (GI). And insulin index of normal amylose versus amylopectin rice varieties (Caroso Pelde, 20% amylose) (Al-Hashimi & Al-Sahi, 2012). Studies by Chi et al. (2021) also showed that rice with a higher percentage of amylose gave a significantly lower glucose index of oligo amylose versus amylopectin rice cultivars. Therefore, the digestibility of starches varies in general as the amylose content increases. However, amylose content alone is not the sole indicator of digestibility, and the amylose complexed with fats is more resistant to attack by hydrolytic enzymes than free carbohydrates (Dupuis et al., 2014).

When starch is heated to a temperature of 50 °C in the presence of water, the amylose swells into the granules, the crystal structure of amylopectin disintegrates, the granules are ruptured, and the polysaccharide chains take a random shape, causing the starch to swell and thicken the matrix and make the starch easy to digest. Higher GI can also affect GL, it deteriorates after the conversion of starch into gelatin (Ali et al., 2021), and when it cools (low temperature), the gelatinous starch gradually begins to rearrange the large amylose and amylopectin molecules, which leads to an increase in the crystalline nature of the starch molecules. With the passage of time and the decrease in temperatures, the higher the amylose in the starch content, the greater the retraction process and the resistance to digestion. The starch will be due to stronger hydrogen bonding, which leads to a lower GI of starch. This may also decrease starch through retraction or gelatinization (Eleazu et al., 2016; Yadav et al., 2013).

Fifth: Glucose Index (GI)

The glycemic index, or the glycemic index, is a system for classifying foods that contain carbohydrates on a scale ranging from 0-100, according to the extent to which they raise blood sugar (glucose) levels when consumed, as some foods can lead to a rise in sugar. In the blood very quickly, for example, "food containing

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carbohydrates such as frequent sugars and bread easily turns into glucose inside the body, while the carbohydrates found in vegetables and whole grains are digested slowly, and when eating food that contains sugar, especially carbohydrates, the blood sugar level rises, in return." The cells of the pancreas begin to secrete the hormone insulin, which carries glucose and enters it into the cells to be used as an energy source. Therefore, eating a lot of easily digestible carbohydrates (raises blood sugar quickly) and gives less opportunity for the body to secrete insulin in appropriate quantities, which leads to difficulty in controlling blood sugar (Turner-McGrievy et al., 2021; Facchinetti et al., 2021; Von Ah Morano et al., 2020;).

Foods with high glucose index (Bad carbs) are quickly digested, absorbed and metabolized within the body, leading to a noticeable fluctuation in blood sugar levels. In contrast, foods with a low glucose index (Good Carbs) show slight blood sugar and insulin level fluctuations. In addition to being considered one of the secrets of maintaining long-term health, it reduces the risk of diabetes and heart disease and is also considered one of the keys to getting rid of excess weight (Lal et al., 2021).

Studies have confirmed that the high GI index in rice causes an increase in the number of people aged 35-44 years with diabetes, and foods that contain a high percentage of the glucose index, which is quickly broken down by the body, include sugar, sugary foods, sugary soft drinks, white bread and potatoes. White rice and others, as for foods with a low glucose index in some fruits, vegetables, legumes, and foods made from whole grains, oats, and others (Li and Hu, 2021).

Reliable glycemic index (GI) tables compiled from the scientific literature are useful in improving the quality of research examining the relationship between GI, glycemic load and health. The glucose index has proven to be a more useful nutritional concept than the chemical classification of carbohydrates (simple or complex, such as sugars or starches, available or unavailable), allowing new insights into the relationship between the physiological effects of carbohydrate-rich foods and health. Several observational studies have shown that chronic consumption of a diet high in glycemic index (Dietary GI carbohydrate content) is independently associated with an increased risk of type 2 diabetes, cardiovascular disease and some types of cancer.

Table 1: The glucose index for some types of rice

No.	Rice type	glucose index g/100 g	Source
1	Amber rice	**79.6 - 55**	**WebMed, Nayar, S., & Madhu, S. V. (2020).**
2	brown rice	**81-54**	**, WebMed, Nayar, S., & Madhu, S. V. (2020).**
3	Basmati rice	**50-58**	**WebMed, Nayar, S., & Madhu, S. V. (2020).**

Sixth: glucose load (GL)

GI-calculated GL is increasingly used in the same way it is intended for glycemic effect and is often given without units but requires units as nutritional value. As it is currently computed from GI, it has a nonlinear error due to the change of glycemic response with dose, as discussed above. If GL is to be used to express the glycemic effect, it must be measured equally if it represents the glucose equivalent of food intake, and then GGE (grams of glucose) will assume the glycemic context (Monro and Shaw, 2008).

Seventh: the glucose index of rice

A study by Madhu and Shikha (2020) showed that eating rice does not increase high blood sugar, while Shobhanae et al. (2017) showed that the glycemic index of white rice is much higher than that of brown rice, causing a rise in the level of sugar in the blood. The research mentioned that genetic manipulation Modern varieties have a significant role in producing a rice crop whose starch content of amylose and dietary fiber is very high, and thus contributes to keeping the glucose index “always” low, taking into account the method of grinding, cooking and cooling, and this is considered a “permanent” solution to the problems of high blood sugar (Aravind et al., 2020).

Eighth: Factors affecting index and glucose load

RGI is an acronym for the glucose effect and includes the glucose index (GI) and the glucose load (GL). An essential factor affecting the GI value of carbohydrate sources is the amylose and amylopectin ratio (Lovegrove et al., 2017). Fats, fibers, and acids (such as lemon juice or vinegar) help lower the glucose index of food, in addition to the fact that the glucose index increases in starches (such as pasta) when cooked over a longer fire (Aleixandre, 2022).

There is a misconception that all sugars have a high glucose index and blood sugar ranges from less than 19 fructose to 105 maltose. Therefore, the rate of sugar in food depends in part on the type of sugar it contains (Qi and Tester, 2020). Studies indicated that the glucose index of fruits increases as they ripen more, as a person can reduce the glucose index of his food as a whole by combining foods with a low glucose index with foods with a high glucose index (Westman et al., 2008). Also, the person's age, physical activity, and health status affect the index and glucose load, as people with diabetes may suffer from complications such as gastroparesis, which leads to delayed gastric emptying and, thus, slow absorption of food.

Boers et al. (2015) indicated in their study on the effect of rice on the glucose index, the study showed that several factors contribute to the effect, including the characteristics of starch (amylose and amylopectin ratio), the type of rice, the method and time of cooking, the method of heating and reheating, and the method of storage, but in all cases, it gives brown rice Glucose index is lower compared to white rice under the same conditions.

The results of Nawaz et al. (2018) study showed that soaking significantly affected rice yield, grain hardness, crystallinity, color, thermal and adhesive properties, textural traits, and glucose index for rice cultivars. Furthermore, physical and chemical changes create more transparency and coloration. These changes also affect cooking properties, such as the firmer texture of cooked beans. Moreover, blanching may increase resistant starch and lower the glycemic index (GI), promoting health.

Ninth: the chemical composition of rice

Awareness of the nutritional value and health benefits of rice is vital to increase the consumption of rice in the daily diet of human beings. Rice is a rich source of carbohydrates, contains a moderate amount of protein and fat, and is also a source of vitamin B complexes such as thiamine, riboflavin, and niacin. The primary carbohydrate of rice is starch, which consists of amylose and amylopectin. Rice grains are 12% water, 75%-80% starch and only 7% protein, with a full range of amino acids. Its easily digestible protein (93%) has an excellent biological value (74%) and protein efficiency ratio (2.02%-2.04%) due to having a higher concentration (about 4%) of lysine. Minerals such as calcium (Ca), magnesium (Mg), and phosphorus (P) are present, along with some iron (Fe), copper (Cu), zinc (Zn), and manganese. Although the nutritional values of rice vary with cultivars, soil fertility, fertilizer use and other environmental conditions, it still exists in comparison to other grains: low-fat content after the bran has been removed and low protein content (about 7% - 10%). And higher protein digestibility. Due to its nutritional quality and easy digestibility, rice is considered the queen among grains. Freshly harvested rice grains contain about 80% carbohydrates which include starch, glucose, sucrose, and dextrin (Verma and Srivastav, 2017).

In a study conducted by Muttagi and Usha (2020), twenty traditional rice varieties grown in Karnataka, de-grained, were evaluated concerning chemical and nutritional properties. Traditional rice varieties differed significantly ($P < 0.05$) for all studied measures. Moisture (8.44-10.04%), Protein (7.63-12.35%), Fat (2.12-3.23%), Fiber (1.29-3.16%), Ash (1.08-1.64%), Carbohydrates (72.85-77.53%), and Energy (353.16-366.91 Kcal) content of traditional rice varieties varied greatly. The minerals iron (1.34–3.36 mg), zinc (2.22–3.72 mg), calcium (18.32–24.07 mg), and phosphorus (225.25–248.41 mg) differed significantly. The content of amylose and total starch ranged from 12.51 to 24.64 per cent and 68.31 to 75.64 percent, respectively. Insoluble, soluble, and total dietary fiber ranged from 4.34 to 9.79, 0.12 to 0.62, and 4.46 to 10.40 grams per 100 grams, respectively.

Table 2: Shows the percentage of chemical components in rice

class	Humidity (g)	Protein (g)	Fat (g)	Fiber (g)	Ash (g)	Carbohydrates (g)	Energy (Kcal)
Long grain	10.60	7.06	2.54	4.06	1.32	75.70	361.06

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Middle grain	10.04	8.51	2.59	3.16	1.56	74.14	353.89
Short grain	9.22	10.49	2.61	2.35	1.47	73.86	360.87

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