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Glycemic Index and glycemic load for different types of cooked rice for healthy volunteers

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The effect of eating different types of rice was studied, including basmati rice, local amber rice, brown rice and diet rice, in addition to bulgur and mung bean on the glycemic response and glycemic Index values. The effect of eating rice cooked by pressing and Boiled methods on the blood sugar response of healthy volunteers was studied, where the results of the study included ten volunteers. The highest increase in blood sugar level response occurred after consuming amber rice cooked by pressing method, which reached 160.3 (mg / 100 ml). After thirty minutes of eating it, while bulgur rice cooked by Boiled method has raised the level of blood sugar response less than rice of all kinds and at a rate of 121.7 (mg / 100 ml) after eating it by thirty, the study determined the glycemic index and blood sugar load for each sample of raw, mixed and cooked rice (pressing and boiled) in addition to bulgur. The results showed a variation in the values of the glycemic index at the level of ($p \geq 0.05$) for different types of rice. The results showed that the highest glycemic index was for amber rice cooked by pressing method with a percentage of (88.8) and the lowest glycemic index was for bulgur cooked by Boiled method by (37). While the glycemic index of white basmati rice in the ways of pressing and Boiled was 66.6 and 53 respectively, and the additions that were added to basmati rice, which included mash, cinnamon and turmeric, had a clear role in reducing the blood sugar index, as the values of the glycemic Index for basmati rice pressed and mixed with mash, cinnamon and turmeric are 60, 56 and 57 respectively, while the values of the glycemic Index for basmati rice mixed with mash, cinnamon and turmeric are 49.2. 48 and 46, respectively.
Keywords: Mung bean rice, Amber rice, Glycemic load, Amylose, Glycemic index.

INTRODUCTION

Rice is one of the most important basic foods for a wide segment of the world's population in general and Asian countries in particular, and it is one of the most important types of Iraqi table meals. Rice is an important source of carbohydrates with an originating content ranging from 70-85% (Fresco, 2005). Several studies have indicated that rice consumption, especially white rice, is associated with higher blood sugar and an increased risk of type II diabetes (Hu *et al.*, 2012). After eating a meal, especially rich in carbohydrates, there is a rapid rise in blood sugar, followed by a rapid decline, and this rise and fall leads to a change in the body's secretion of hormones such as adrenaline, insulin and cortisol (stress hormone) and the combined effect of these hormones makes a person feel tired and more stressed, while the body converts more energy into fat, increases the feeling of hunger and increases inflammation, which in turn can cause damage to some body systems and organ functions and may lead to increased pain and the risk of chronic diseases such as heart disease (Basim *et al.*, 2021). The blood glycemic index is a way to classify foods based on the extra blood glucose responses produced by a certain amount of carbohydrates. The food glycemic Index is the result of action as a result of digestion and absorption of food, as it leads to a change in the level of glucose in the blood and is expressed in the measured area under the blood glucose response curve after fasting or food under test, attributed to the measured area under the blood glucose response curve to white bread or glucose (Raben, 2022). Foods are classified according to the glycemic Index into three groups: foods with a high glycemic Index ≥ 70%), foods with a low glycemic Index ≤ 55%) and

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foods with a (average glycemic Index 55-69%). (Riccardi *et al*., 2003). Medium-term studies of diabetes have shown that replacing carbohydrates with a high glycemic Index such as white bread and potatoes with low glycemic index values such as whole grains and legumes will improve blood sugar control and reduce episodes of hypoglycemia among people treated with insulin (Pathiwada, 2023). The digestion of carbohydrates in foods is influenced by many factors, including the quantity and composition of carbohydrates, their content of monosaccharides and starch, the method of cooking or processing food, as well as the presence of other food components (Hafeel *et al*., 2016). The study aims to identify the effect of eating different types of rice on the glucose response in the blood of healthy volunteers by estimating the glycemic Index and glycemic load for them after eating these different types, which would provide nutritional information for diabetics and healthy people about the impact of rice consumption of different types and the way it is prepared on public health, especially in light of the continuous need to develop healthy food sources.

MATERIALS AND METHODS

This study was conducted at the University of Basra, College of Agriculture, Department of Food Science for the year 2021, where four varieties of rice were selected (brown, diet, amber and basmati) in addition to bulgur and legumes, including mung bean, as well as the selection of spices from local markets in Basra. Rice varieties were cooked in two ways (Boiled and press). The humidity was estimated by weighing 5 g of the studied samples ground in a moisture dish and then placed in an air oven at a temperature of 105°C, after which the percentage of humidity was estimated according to the following equation:

Humidity Celsius % = (Weight of the dish with the sample before drying - Weight of the dish with the sample after drying)/ (sample weight) ×100

The percentage of ash was estimated by burning a weight of 2 g of each sample in a ceramic lid and placed in an incineration furnace at a temperature of 550°C for 6 hours and the percentage of ash was calculated according to the following equation:

Ash percentage % = (Sample weight with eyelid before incineration - Sample weight with eyelid after incineration)/ (sample weight) ×100

The fats were estimated by taking a known weight from each sample and placing them in the Soxhlet device and the percentage of fat was estimated according to the following equation:

Fat Percentage % = (Fat + Decanter) - Empty Decanter Weight)/ (Sample Weight) ×100

Estimation of total protein of samples based on nitrogen percentage using Micro-Kjeldahl method. The percentage of fiber was estimated after fat extraction from Soxhlet device for samples and calculated accordingly:

Fiber percentage % = (Weight of the eyelid with the sample after incineration - Weight of the eyelid with the sample after drying)/ (sample weight) ×100

Estimation of carbohydrates percentage:

The starch was extracted from rice.

1. NaOH solution: by dissolving 4.1 g of sodium hydroxide with distilled water and then complete the volume to 1000 ml until mark.
2. The starch was extracted from the types of rice by soaking 500 g. of rice in 1000 ml of sodium hydroxide solution at a concentration of (N 0.1%) for 18 hours, then mixed with a blender for 4 minutes and then filtered with a sieve, centrifuged for 20 minutes several times until the yellow layer was eliminated and adjusted to (6.5 pH) by hydrochloric acid (0.1N) and then left to dry at a temperature of 40°C.

Estimation of amylose percentage: Standard solutions were prepared as an iodine solution was made by dissolving 1 g of iodine with 10 g of potassium iodide with distilled water and then complete the volume to 500 ml. Prepare the standard amylose solution by dissolving 0.1 g of amylose in 10 ml of 1NOH and complete the volume to 100 ml with distilled water. The work was done by weighing 0.1 g of natural starch samples and adding to it 1 ml of methanol alcohol 99% and 10 ml of sodium hydroxide NaOH (1N) and leaving 12 hours at a temperature of 4 m and then complete the volume to 100 ml with distilled water to the mark, take 2.5 ml of the mixture and add 20 ml of distilled water and three drops of phenonophthalene indicator and then add drops of hydrochloric acid 0.1 HCI N until the pink color disappears, then add 1 ml of iodine solution The volume was completed to 50 ml with distilled water and the absorbance was calculated at a wavelength of 590 nm. The titration curve of the standard amylose was prepared by taking 0.2, 0.4, 0.6, 0.8 and 1 ml of the standard amylose solution corresponding to the concentrations of 0.4, 0.8, 1.2, 1.6 and 2 mg / 100 ml and added 1 ml of iodine for each volume and then completed the volume to 50 ml with distilled water and calculated the absorption of the solution at the same wavelength and drew the titration curve of the standard amylose and then according to the amylose in the sample, the picture solution was prepared by taking 1 ml of iodine and completed the volume to 50 ml water Distilled and calculated the absorbency at the same wavelength.

Amylose % = ((100/25)* X / 1000* 0.1 gm)* 100

X= mg100/ml of amylose concentration from titration curve

Dilution Factor = 100/2.5

The percentage of amylopectin is calculated from subtracting the percentage of amylose from 100.

***Food applications*:** The rice samples were prepared for cooking by washing the samples with running water, soaking and filtering them according to the method (*Alshekh et al*., 2014) with some modifications.

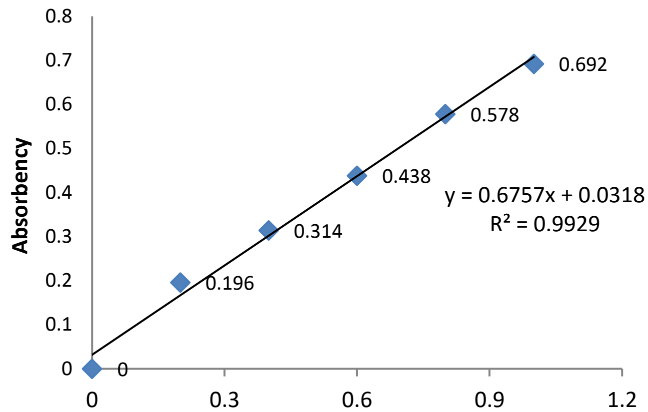

Figure 1. Standard amylose curve

***Cooking method with boiled*:**

1- Brown rice: Add 100 g of brown rice to 500 ml of water and add 1.5 g of table salt in a cooking pot, then kept for 35 minutes, then filtered the water and kept at low heat until fully cooked, according to the method of (Alshekh *et al*., 2014).
2- White rice: This method was followed to prepare each of (basmati rice, amber rice and diet rice) by adding 100 g in a cooking pot to 200 ml of water and adding 1 g of table salt and leaving it for 20 minutes, then filtering the water and kept on low heat until full maturity according to the method (Alshekh *et al*., 2014).
3- Bulgur: Add 100 g of bulgur to 500 ml of water and add 1.5 g of table salt in a cooking pot and leave it for 35 minutes, then filter the water and return on low heat until fully cooked, according to the method (Alshekh *et al*., 2014).
4- Mung bean rice: Add 75 g of rice and 25 g of mash to 500 ml of water and add 1.5 g of table salt and leave it for 20 minutes and then filter the water and re-heat until fully cooked.
5- Cinnamon rice: Add 90 g of rice and 10 g of cinnamon to 200 ml of water and add 1 g of table salt and leave it for 20 minutes, then filter the water and re-heat until fully cooked.
6- Turmeric rice: 98 g of rice and 2 g of turmeric were added to 200 ml of water and add 1 g of table salt and leave it for 20 minutes, then filtered the water and re-over low heat until fully cooked.

***Cooking method with press*:**

1- 1-Brown rice: Add 100 g of brown rice after washing and soak it on 8 g of olive oil in a cooking pot for several minutes, stirring, then add 500 ml of water and 1.5 g of table salt and leave for 35 minutes until fully cooked, according to the method (Alshekh *et al*., 2014).
2- White rice: I followed the method of Alshekh *et al*. (2014) to prepare each of (basmati rice, amber rice and diet rice) by adding 100 g in a cooking pot to 8 g of olive oil in a cooking pot for several minutes, stirring, then add 200 ml and 1 g of table salt and then leave for 20 minutes until fully cooked.
3- Bulgur: Add 100 g of bulgur to 8 g of olive oil in a cooking pot for several minutes, stirring, then add 500ml

Table 1. Ingredients used in cooking and the person's portion intake.

Simple	Rice\gm	Additions	Water volume	Fat\gm	Per person's share intake\gm
Boiled brown rice	100		500	0	191.00
Boiled basmati rice	100		200	0	196.00
Boiled amber rice	100		200	0	158.29
Boiled diet rice	100		200	0	206.19
Boiled mung bean rice	75	25 gm Mung bean	500	0	197.60
Boiled cinnamon rice	90	10 gm Cinnamon	200	0	207.00
Boiled turmeric rice	98	2 gm turmeric	200	0	186.51
Boiled bulgur	100		500	0	268.58

Table 2. Ingredients used in cooking and the person's portion consumed for diabetes screening.

Simple	Rice\gm	Additions	Water volume	Fat\gm	Per person's share intake\gm
Press brown rice	100		500	8	159.40
Press basmati rice	100		200	8	136.51
Press amber rice	100		200	8	132.08
Press diet rice	100		200	8	166.28
Press mung bean rice	75	25 gm Mung bean	500	8	156.46
Press cinnamon rice	90	10 gm Cinnamon	200	8	164.80
Press turmeric rice	98	2 gm turmeric	200	8	148.86
Press bulgur	100		500	8	235.00

of water and 1.5g of table salt and leave for 35 minutes until full maturity (Alshekh *et al*., 2014).

4- Mung bean rice: Add 75 g of rice and 25 g of mash to 8 g of olive oil in a cooking pot for several minutes, stirring, then add 500 ml of water and 1.5 g of table salt and leave for 20 minutes until fully cooked.
5- Cinnamon rice: Add 90g of rice and 10g of cinnamon to 8g of olive oil in a cooking pot for several minutes, stirring, then add 500 ml of water and 1 g of table salt and leave for 20 minutes until fully cooked.
6- Turmeric rice: 98 g of rice and 2 g of turmeric were added to 8 g of olive oil in a cooking pot for several minutes, stirring, then add 200 ml of water and add 1 g of table salt and leave it for 20 minutes until full maturity.

The response of blood glucose to food was with the participation of (10 volunteers) males and females, after the body mass (BMI) was determined, the volunteers were healthy. At the beginning of the experiment, each participant underwent a glucose tolerance test, where each participant consumed 50 grams of glucose dissolved in 250 ml of water. After that, the participating volunteers ate the tested food, as each food contained 50 grams of carbohydrates after fasting for 12 hours overnight fasting and before eating lunch, blood samples were taken from the finger of the hand in the zero time, after which the participants ate the food with 250 ml of water. Where eating lunch took 5-10 minutes. Blood samples were taken after eating food from the finger at (15-30-45-90-60-120) minutes. Each participant also ate all types of food as well as a standard food (glucose solution) containing 50g glucose, and there was at least a week between measurements, and blood samples taken from the participating volunteers were measured directly using one touch test strips. The classical index for each food was calculated after the completion of blood glucose response tests, by calculating the increase in the area under the glycose response curve for two hours, the increase in the area under the glycemic response curve for the same period of the standard food (glucose) and multiplying the ratio ×100. The area under the glycose response curve is calculated while ignoring the area below baseline (below fasting level) FAO (1980). The area under the curve was calculated arithmetically and using an electronic calculator, taking into account the standard food glycemic Index (glucose) = 100. The classical load was measured after the completion of the classical index measurement through calculating the classical load:

Glycemic load = Glycemic index × carbohydrate weight in grams / 100

The data results were analyzed on the basis of a complete randomized design (CRD) for all experiments. The data were analyzed using the GenStat, 2009 statistical analysis software and the significant differences between the averages were compared with the test of the lowest significant difference L.S.D. below the level of significance 0.05.

RESULTS AND DISCUSSION

The results in Table 3 showed the chemical composition of the studied raw samples that the percentage of moisture varied in the samples, where both basmati and brown rice showed the highest moisture percentage compared to the rest of the rice samples, where the moisture percentage was (11.183%) and (10.579%) for basmati and brown rice respectively, the lowest moisture percentage was in bulgur compared to the rest of the samples, where the moisture percentage was (9.648%). The results of the moisture content of basmati rice agreed with Upadhyay and Kumarkarn (2018) where it was shown that the moisture content of raw basmati rice is 11.62% when studying the nutritional composition and health benefits of brown rice. In addition, the results showed that the percentage of fat content varied in the studied rice samples, where brown rice showed the highest percentage of fat content compared to other samples, where the percentage of fat content (2.741%) for brown rice The results were similar to what Oko and Ugwu (2011) found, where he showed that the percentage of fat in white rice ranges between (0.5-3.5%) and the reason for the low fat content in the types of white rice compared to brown rice is due to the process of processing rice by removing the outer layer of the grain that reduces the fat content of rice grains because the fat is concentrated in this layer (Otemuyiwa *et al*., 2018). The results of the same table showed a variation in the ash percentages of the studied samples, where the mung bean showed the highest ash percentage compared to other types, where the ash percentage was (2.6070%), which is lower than what was reached by (Zafar *et al*., 2023). The ash percentages range between (-0.88 1.67%) for the different types of rice used in his study. The

Table 3. Chemical composition of raw samples used in the study.

Test simple	Moisture content %	Fat content %	Ash amount %	Fiber content %	Protein content %	Carbohydrate content %
Brown rice	10.579	2.741	1.3963	3.004	8.683	73.59
Diet rice	10.124	1.018	0.6967	2.531	11.424	74.21
Basmati rice	11.183	1.463	0.7243	1.477	8.071	77.07
Amber rice	10.134	1.890	0.5120	1.550	7.799	78.11
Bulgur	9.648	1.434	1.2983	11.800	11.577	64.24
Mung bean	10.228	1.499	2.6070	11.316	24.641	50.29

results in Table 3 showed that the percentage of fiber content in bulgur (11.800%) was the highest compared to other studied samples. The percentage of mash fiber was (11.316%), which is higher than that of (Zafar *et al*., 2023), which ranged between) 6.17-6.76%. The percentage of protein content of the studied samples in the mung bean and bulgur was (24.641% and 11.577%) respectively, and the percentage of protein in the mash was close to what was reached by the mechanism of Sen Gupta *et al*., (2022) compared to the rest of the species. Another study showed that the crude protein content was higher than 9% in all red and white basmati varieties tested, which is within the limits of the average content of The crude protein of rice mentioned in previous studies, which was in the range of 11-7% (Naveed *et al*., 2022), which is similar to what was stated in this study, the percentage of carbohydrate content in amber rice was (78.11%) and was higher than the rest of the studied types.

The results showed in Table 4 the percentage of extraction of starch from the types of rice used in the study, where the results showed that the extraction rate varied in the samples, where amber rice showed the highest extraction rate with significant differences at the level of ($p>0.05$) by (53.72%) compared to brown rice, basmati rice and diet rice by percentages of (45.07%, 48.39% and 40.85%) The reason is due to differences in the genetic makeup of grain species and different environmental conditions (Shi *et al*., 1994). The results also show a variation in the percentage of amylose in diet rice (33.433%) compared to amber, basmati and brown rice by (27.783%, 28.730% and 30.227%) respectively. These results were similar to the findings of Alzaidi and Alhashmi, 2018, as it was found that the percentage of amylose for the emergence of natural rice reached 30.10% variation in amylopectin content in amber rice (72.233%) Compared to brown rice, diet and basmati (69.773%, 66.567% and 71.270%). Amylopectin levels were higher than amylose levels in all rice studied. Also, the highest levels of amylose were found in diet rice (33.433%) and the highest percentage of amylopectin in amber rice (72.233%). High-amylose cooked rice has slower digestion, giving nutritional benefits including sugar regulation in people with diabetes, but rice has poor qualities (Tao *et al*., 2019).

Table 4. Extraction ratio and percentage of amylose and amylopectin in extracted starch.

Simple	Extraction ratio %	Amylose ratio %	Amylopectin ratio %
Brown rice	45.07	30.227	69.773
Diet rice	40.85	33.433	66.567
Amber rice	53.72	27.783	72.233
Basmati rice	48.39	28.730	71.270
L.S.D	0.681	0.4169	0.4222

For the purpose of studying the effect of consumption of cooked rice on blood sugar, the following were selected:

1- Body mass index for volunteers: This study included ten volunteers, the volunteers included five males and five females, all of whom have good health and a normal blood sugar level. The volunteers ranged in age from 20 to 40 with a BMI of 18.86 to 22.58 kg/m².
2- The effect of consumption of rice types cooked by pressing and boiled method on the rate of blood sugar response of volunteers: Figure (2) illustrates the effect of consumption of studied samples (bulgur, brown rice, basmati rice, diet rice and amber) cooked by pressing method on changing the level of blood sugar response of volunteers compared to changing the level of blood sugar response to them after eating glucose. Where the highest rise in the blood sugar level response occurred after eating amber rice, which reached 160.3 (mg / 100 ml) after thirty minutes of eating it, while the lowest rise in the level of blood sugar response occurred after eating diet rice, where the level of sugar response 122.5 (mg/100ml), a slight difference from bulgur, which reached 125.6 (mg/100ml) thirty minutes after consuming them.

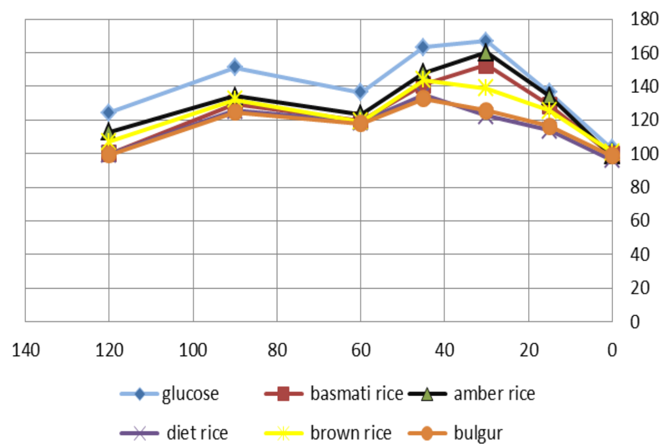

Figure 2. Effect of consumption of rice samples cooked by pressing method on changing the level of blood sugar response within 120 minutes

Figure 3 showed the effect of consumption of studied samples (bulgur, brown rice, basmati rice, diet rice and amber) cooked by puncture method on the change in the level of response of volunteers' blood sugar compared to the change in their blood sugar response level after eating glucose. The results showed that bulgur rice raised the level of blood sugar response less than the rest of the types and at a rate of 121.7 (mg / 100 ml) thirty minutes after eating it, while the boiled amber rice showed the highest increase in the level of blood sugar response of volunteers thirty minutes after eating it at a rate of 152 (mg / 100 ml).

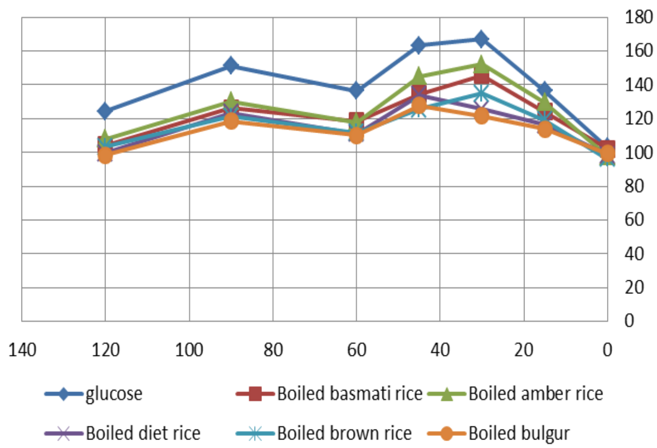

Figure 3. Effect of consumption of rice samples cooked by boiled method on changing the level of blood sugar response within 120 minutes.

Figures 4 and 5 showed the effect of consuming mung bean, cinnamon, turmeric and basmati cooked by pressing and boiled methods on changing the level of blood sugar response within 120 minutes compared to changing the level of blood sugar response to them after eating glucose. Where the results show that cinnamon rice has raised blood sugar to 142.9 after thirty minutes of eating and its effect was less than the effect of other types, as turmeric rice, mung bean rice and basmati rice raised blood sugar to (145.6, 147.8 and 152.8 mg / 100 ml) thirty minutes after eating it. In addition, the effect of cinnamon rice on blood sugar was lower than the rest of the other types (basmati, turmeric and mung bean) cooked by boiled method thirty minutes after eating these types, the sugar response rate of cinnamon rice was 135.9, while the response rates for the rest of the types (145.5, 137 and 140. mg/100ml) respectively

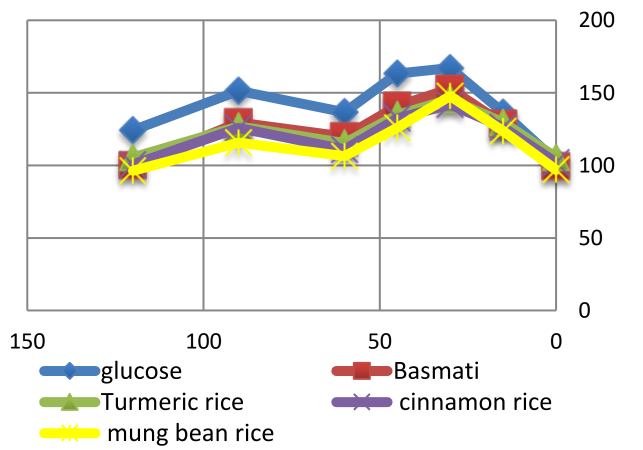

Figure 4. Effect of consumption of mung bean, cinnamon, turmeric and basmati cooked by pressing method on changing the level of blood sugar response within 120 minutes.

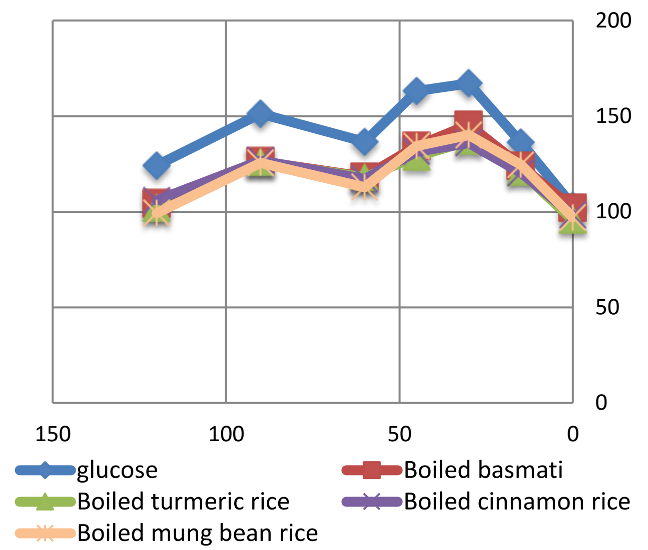

Figure 5. Effect of consumption of mung bean, cinnamon, turmeric and basmati cooked by boiled method on changing the level of blood sugar response within 120 minutes.

Figure 6 illustrates the effect of consumption of diabetic rice samples cooked by boiled method and pressing method on the change in the level of blood sugar response of volunteers compared to the change in their blood sugar response level after eating glucose. The results showed that the press diet rice raised the level of glycemic response by 134.7 (milligram/100ml) forty-five minutes after eating it compared to the boiled diet rice, which raised the level of glycemic response by 133.7 (milligram/100 ml) forty-five minutes after eating it.

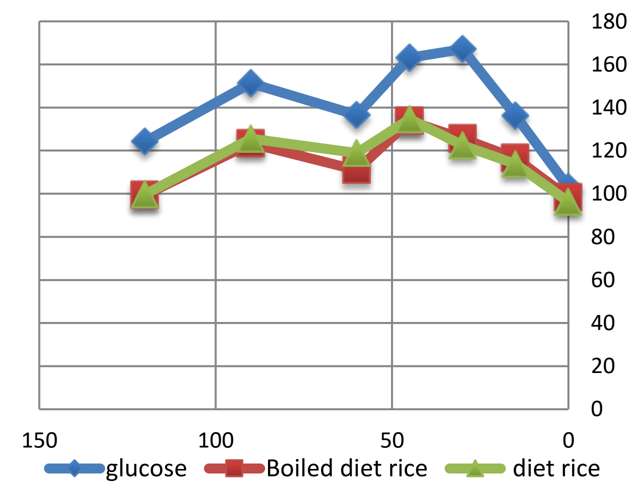

Figure 6. Effect of consumption of cooked diet rice by pressing and boiled method on changing the level of blood sugar response within 120 minutes.

Figure 7 shows the effect of consumption of amber rice samples cooked by boiled method and pressing method on the change in the level of response of the volunteers' blood sugar compared to the change in the level of their glycemic response after eating glucose. The results showed that amber rice raised the level of blood sugar response by 160.3 (mg / 100 ml) thirty minutes after eating it when cooked by pressing method, while the blood sugar response level was raised by 152 (mg / 100 ml) thirty minutes after eating it when cooking it by boiled method.

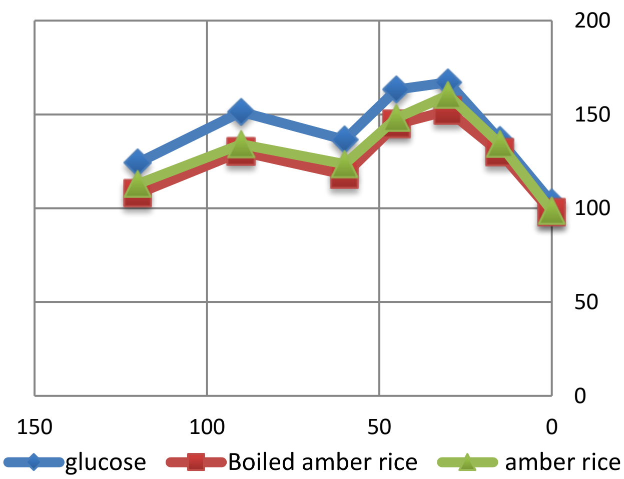

Figure 7. Effect of consumption of amber rice cooked by pressing and puncture method on changing the level of blood sugar response within 120 minutes.

Figure 8 showed the effect of consumption of brown rice samples cooked by boiled method and pressing method on changing the level of blood sugar response of volunteers compared to changing the level of blood sugar response to them after eating glucose, where the results showed that brown rice cooked by pressing method raised the level of blood sugar response to 138.8 (mg / 100 ml) thirty minutes after eating it, which had a higher effect than brown rice cooked by boiled method, which raised the level of glycemic response to 125.6 (mg/100ml) Thirty minutes after eating.
Figure 9 illustrates the effect of consumption of bulgur samples cooked by boiled method and pressing method on the change in the level of response of the volunteer blood sugar compared to the change in the level of their glycemic response after eating glucose. Like the rest of the results, press-cooked bulgur raised the glycemic response by 132.8 (mg/100ml) forty-five minutes after ingestion, while boiled bulgur raised the glycemic response level by 127.7 mg / 100ml forty-five minutes after consumption.

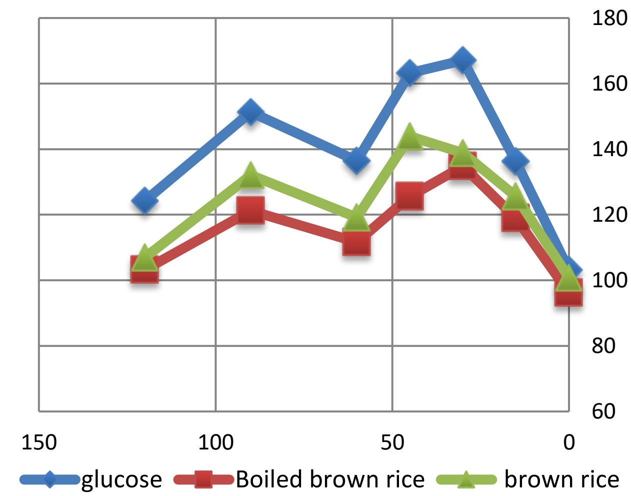

Figure 8. Effect of consumption of brown rice cooked by pressing and puncture method on changing the level of blood sugar response within 120 minutes.

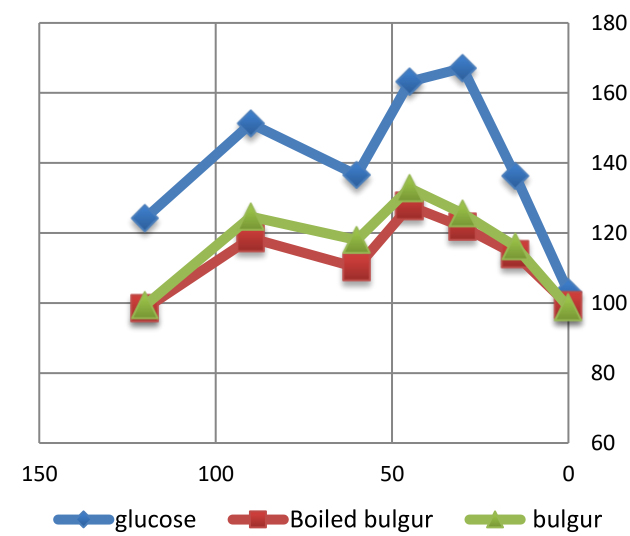

Figure 9. Effect of consumption of bulgur cooked by pressing and boiled method on changing the level of blood sugar response within 120 minutes.

Figure 10 illustrated the effect of consumption of basmati rice samples cooked by boiled method and pressing method on the change in the level of blood sugar response of volunteers compared to the change in the level of blood sugar response to them after eating glucose. The glycemic response level increased to 145.5 and 152.8 mg (100ml) thirty minutes after eating boiled and pressing basmati rice, respectively.

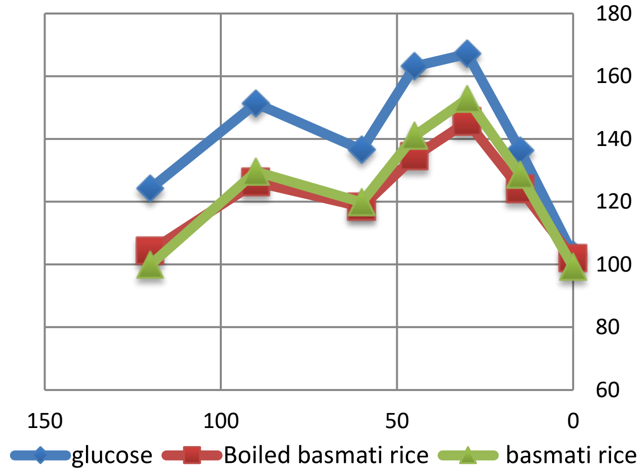

Figure 10. Effect of consumption of basmati rice cooked by pressing and boiled method on changing the level of blood sugar response within 120 minutes.

Figure 11 illustrates the effect of consumption of mung bean rice samples cooked by boiled method and pressing method on the change in the level of response of volunteers' blood sugar compared to the change in the level of blood sugar response to them after eating glucose. The results show that pressed mung bean rice raised the blood sugar response level to 147.8 mg / 100 ml after thirty minutes of eating compared to the boiled mung bean rice, which raised the blood sugar response level to 140.1 mg / 100 ml thirty minutes after eating.

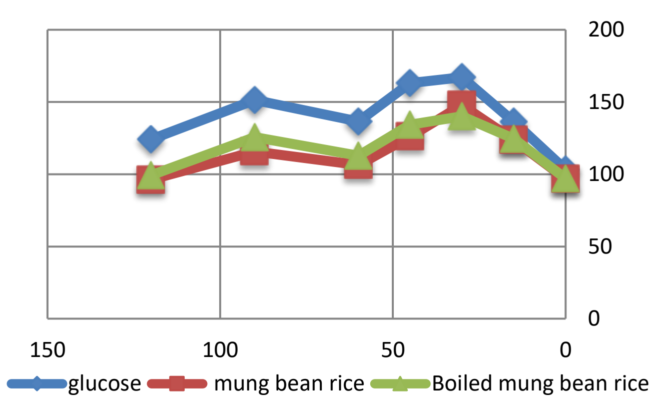

Figure 11. Effect of consumption of cooked mash rice by pressing and boiled method on changing the level of blood sugar response within 120 minutes.

Figure (12) shows the effect of consumption of basmati rice samples cooked with turmeric by boiled method and pressing method on the change in the level of blood sugar response of volunteers compared to the change in the level of blood sugar response to them after eating glucose. The results showed that the level of blood sugar response increased thirty minutes after eating turmeric rice by pressing and boiled method to 145.6 and 137 (mg/100 ml) respectively.

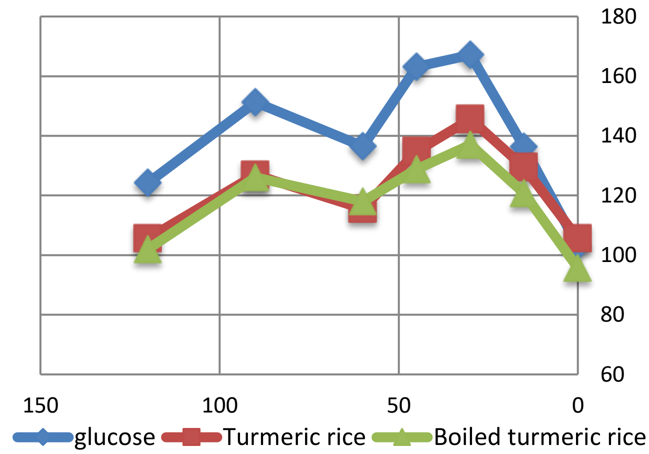

Figure 12. Effect of consumption of basmati rice with turmeric cooked by pressing and boiled method on changing the level of blood sugar response within 120 minutes.

Figure 13 shows the effect of consumption of basmati rice samples cooked with cinnamon by boiled method and pressing method on the change in the level of blood sugar response of volunteers compared to the change in their blood sugar response level and glucose intake. The results showed that cinnamon rice by pressing method increased the level of blood sugar response by a higher score than cinnamon rice by boiled method by 141.9 and 135 (mg/100 ml) respectively after thirty minutes of consuming.

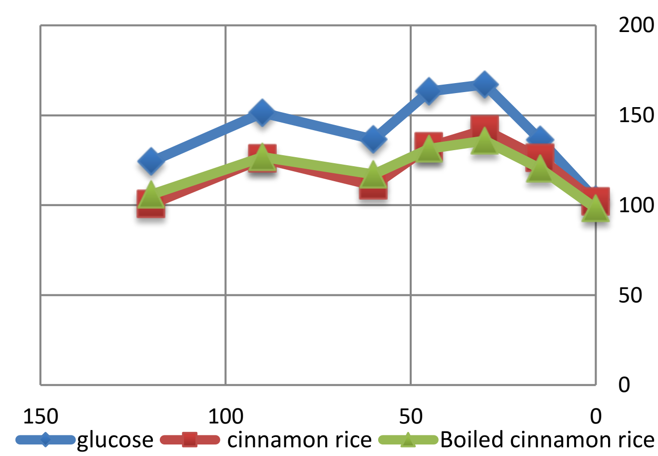

Figure 13. Effect of consumption of basmati rice with cinnamon cooked by pressing and boiled method on changing the level of blood sugar response within 120 minutes.

Rice is one of the most important main dishes on the table of most people, and the effect of its consumption on the health of these people consuming it is due to the increased load of blood sugar in them. Therefore, the low glycemic index of rice contributes to reducing the glycemic load (Atkinson *et al*., 2021). Through the results shown in figures 2 to 12, it is clear that the pressing method has raised the level of blood sugar in most types and mixtures of rice consumed compared to the boiled method, and the reason may be due to the low carbohydrate content in the boiled method, in addition to the role of the boiled process in getting rid of starchy materials. Han and Lim (2009) noted that soluble starches, especially amylose, often leak from rice after soaking and leak more after boiling rice. The above figures also showed that sugar rice was the best type of rice to lower the glycemic response due to the fact that these effects occur due to differences in physical and chemical properties and the processing and cooking time of rice varieties. In addition, the reason may be that sugar rice contains the highest amylose content among the types used as shown in Table 4 by 33.433% compared to other varieties. The results also showed that bulgur had outperformed all types of rice in the study in the blood sugar response because it contains a high percentage of fiber as shown in Table 3. Bulgur is a nutrient-rich food product made from fiber-rich whole wheat grains and is a rich source of vitamins, minerals, proteins and other active substances It is one of the healthy foods that have proven its nutritional and therapeutic properties in many studies that it is one of the foods that reduce the risk of chronic diseases, including diabetes, and also helps in weight loss, increased digestion and intestinal health, and that eating it may cause a slight increase in blood glucose (Shah *et al*., 2022). Rice is a starchy diet where nutrients and fiber are stripped of it, leading to high blood sugar. The mung bean is classified as having a low glycemic Index As shown in Table 5 and the fiber content is very high and the carbohydrate content is low, mixing mung bean with rice in addition to its role in improving the nutritional value of the meal and increasing the proportions of proteins, fats, fiber and other nutrients, it helps in controlling the high level of glucose in the blood and is a good alternative in healthy diets. (Basim *et al*., 2021). It is also clear from the results of the study that brown rice was better than white rice in controlling the rise in the percentage of blood glucose response, and the reason for this is due to the fact that brown rice contains a high percentage of 3.004% compared to white rice and a high percentage of amylose, which was shown in Table 4 by 30.227%, and these results are consistent with one of the studies that found that replacing white rice with brown rice, may reduce the risk of type II diabetes through its effect on Lowering blood glucose and improving insulin response among adult study participants In this study . The study also showed that white basmati rice has caused a significant rise in blood sugar response and may be due to the fact that it contains less fiber than other varieties studied. Saronee *et al*. (2019) found that turmeric has the ability to reduce blood sugar in a group of mice with diabetes After taking low doses of it, the glycemic effect of turmeric was inferred in its interpretation to the chemical composition of turmeric, as it contains many active compounds such as triterpenoids, glycosides, flavonoids, tannins, curcumin and sterol compounds, where compounds play an important role contributing to alleviating diabetes-related complications by stimulating insulin from the remaining beta cells, promoting the transport of glucose to the tissues of the body, and inhibiting the absorption of glucose by the digestive system. The results also showed that cinnamon rice has reduced the blood sugar response. Compared to rice The reason is attributed to the sugar-lowering role of cinnamon. The mechanisms that explain the role of cinnamon in lowering glucose and improving insulin resistance are not entirely clear, but laboratory, animal and human studies have suggested a range of possibilities, including that cinnamon contains a high percentage of (proanthocyanidin), as a plant metabolite product that has antioxidant activity. Moreover, cinnamon bark extracts prevented the formation of advanced glucose end products (AGEs) in vitro that contribute to diabetes complications, and the results of the study showed that the consumption of Iraqi amber rice has caused a clear increase in the level of glucose sugar response compared to the rest of the rice varieties, which may be due to the low percentage of fiber. The high percentage of carbohydrates as shown in Table 3 by 78% in addition to the quality of starch that had a high content of amylopectin as shown in Table 4. It can also be attributed to the change in the quality of starch after cooking. Table 5 shows the glycemic index and blood sugar load for each sample of raw, mixed and cooked rice (boiled and pressing) in addition to bulgur. The results showed a variation in the values of the glycemic index at the level of ($p \geq 0.05$) for different types of rice. The results showed that the highest index of blood sugar was for amber rice cooked by pressing and boiled methods at rates of (88.8 and 73.5) respectively, which was superior with significant differences at the level of ($p > 0.05$) compared to all types of rice studied, while the lowest significant value was at the level of ($p > 0.05$) of the glycemic index, which amounted to 37 was after eating bulgur cooked by boiled method. While the glycemic index of basmati white rice by pressing and puncture methods reached 66.6 and 53 respectively, which significantly exceeded the level of ($p > 0.05$) with all types of rice and additives except amber rice. The additions added to basmati rice, which included mung bean, cinnamon and turmeric, had a clear role in reducing the blood sugar index, as the values of the glycemic Index for pressed basmati rice mixed with mung bean, cinnamon and turmeric were 60, 56 and 57 respectively, while the values of the glycemic Index for boiled basmati rice mixed with mung bean, cinnamon and turmeric were 49.2, 48 and 46, respectively. Through these results, it is clear that the highest glycemic index for the types of rice studied was when eating Iraqi amber rice, and the reason for this may be due to the nature of the chemical composition of this type of rice and its content of nutrients and the high percentage of carbohydrates in it One of the researches in which the correlation coefficient between the glycemic index and the additional area under the curve with the nature of nutrients and energy in some diets indicated that there is a weak negative correlation between the glycemic index and the additional area under the curve with the percentage of moisture and the content of the meal from and a negative correlation medium to strong with the amount of protein, fat, total dietary fiber and soluble dietary fiber in the meal and a weak positive correlation with The amount of carbohydrates and minerals and that increased blood glucose can be prevented after eating in the management of diet for type II diabetes by considering the type of diet, the amount of protein, fat, and total and soluble dietary fiber (Hakimah *et al*.2020). The study also showed the glycemic index after eating raw basmati rice cooked by pressing method was also high and that the boiled process had reduced the value of the index. The glycemic index decreases with the amylose content in basmati rice (Naveed *et al*., 2022). The two scientists also explained that the protein content also affects the glycemic response index of both brown and white rice. One study also confirmed that eating white rice is positively associated with the risk of type II diabetes, while reducing the intake of type II diabetes While eating brown rice reduces the risk of developing this disease, replacing white rice with brown rice or whole grains can be a successful strategy in improving diet quality and reducing the risk of type II diabetes. (Yu *et al*., 2022) The difference in the values of the glycemic index between the types of rice in the study may also be attributed to the effect of the different varieties and geographical areas in which these varieties are cultivated on the physical and chemical properties of rice grains, which will contribute to the difference in the values of the glycemic index. Cooking methods also differ on the glycemic index. During cooking, heat and water soften the solid, compact starch grains, causing the water to absorb, swell and eventually tea. As a result. Another study suggested that the way rice is prepared and the thermal processes it is exposed to may affect the glycemic response index. In addition, the manufacturing processes to which raw rice is exposed, such as removing the husk, blending, grinding or mashing, contribute to reducing the size of the grains and increasing the surface area of the grains, making them vulnerable to amylose-degrading enzymes and thus reducing the percentage of amylose and affecting the glycemic response index (Singh *et al*., 2021). From examining the results of the study, we note the preference of the puncture method for cooking rice over the pressing method for cooking rice in reducing the glycemic Index in rice, which makes the use of this method of health importance compared to the traditional cooking method. As for the effect of the additives that were added to basmati rice, the study showed that the additives contributed significantly to reducing the values of the blood glycemic Index, as mung bean rice showed low glycemic Index values compared to raw basmati rice, which may return the effect of fiber in mung bean in reducing its value, as other additions to cinnamon rice and turmeric showed an effect almost similar to mung bean A study by Anusha *et al*. (2018) also showed that turmeric has the ability to lower the glycemic response index and may be due to the fact that it contains some active ingredients. The study showed that all types of rice studied raised the blood sugar index higher than bulgur, which showed a low sugar index, which may be due to containing a high fiber percentage, as Table 5 shows the blood sugar load for each sample of raw, mixed and cooked rice samples (boiled and pressing) in addition to bulgur. The results showed a variation in the values of blood sugar load at the level of ($p \geq 0.05$) for different types of rice. The results showed that the highest blood sugar load was for amber rice cooked by pressing and boiled methods at rates of (44.4 and 6.75) respectively, which was superior with significant differences at the level of ($p > 0.05$) compared to all types of rice studied, while the lowest significant value was at the level of ($p > 0.05$) of blood sugar load, which amounted to 18.5 after eating bulgur cooked by boiled method. The additions added to basmati rice, which included mung bean, cinnamon and turmeric, had a clear role in reducing the blood sugar load, as the glycemic load values for pressed basmati rice mixed with mung bean, cinnamon and turmeric were 30, 28 and 28.5 respectively, while the glycemic load values for boiled basmati rice mixed with mung bean, cinnamon and turmeric were 24.6, 24 and 23 respectively. The lowest value of sugar load was for bulgur cooked by boiled method by 18.5 through the results show that amber rice high glycemic load and bulgur average glycemic load.

Table 5. Index and glycemic load of the studied rice and bulgur samples (boiled and pressing).

Simple	Cooking method	Glycemic Index	Glycemic load
Amber rice	Pressing	88.8	44.40
	Boiled	73.5	36.75
Basmati rice	Pressing	66.6	33.30
	Boiled	53.0	26.50
	Pressing with cinnamon	56.0	28.00
	Boiled with cinnamon	48.0	24.00
	Pressing with turmeric	57.0	28.50
	Boiled with turmeric	46.0	23.00
	Pressing with mung bean	60.0	30.00
	Boiled with mung bean	49.2	24.60
Brown rice	Pressing	62.0	31.00
	Boiled	52.0	27.00
Diet rice	Pressing	54.7	27.35
	Boiled	46.5	23. 25
Bulgur	Pressing	49.0	24.50
	Boiled	37.0	18.50
L.S.D		3.72	1.86

Conclusion**:** The results showed that the highest glycemic index was for amber rice cooked by pressing method with a percentage of (88.8) and the lowest glycemic index was for bulgur cooked by Boiled method by (37). While the glycemic index of white basmati rice in the ways of pressing and Boiled was 66.6 and 53 respectively, and the additions that were added to basmati rice, which included mung, cinnamon and turmeric, had a clear role in reducing the blood sugar index, as the values of the glycemic Index for basmati rice pressed and mixed with mung, cinnamon and turmeric are 60, 56 and 57 respectively, while the values of the glycemic Index for basmati rice mixed with mash, cinnamon and turmeric are 49.2. 48 and 46, respectively.

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