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Research Article

Glycemic Index and Glycemic Load of Selected Omani Rice Dishes

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Abstract: Rice (Oryza sativa) is one of the most important cereal grains that is popularly consumed globally as a staple food. A number of rice dishes are prepared and consumed in Oman. Representative samples of four different types of cooked rice dishes (White rice, Brown rice, Kabuli rice, and Biryani rice) and two traditional dishes (Arsiya and Harees) were collected from local restaurants. The aim of this study was to evaluate the proximate composition, glycemic index (GI) and glycemic load (GL) of these dishes. The results indicated significant ($P < 0.05$) differences in the proximate composition, GI, and GL values of differently cooked rice dishes as well as for Arsiya and Harees. With the exception of white rice which showed the highest glycemic index value (77.3), all other three rice dishes as well as Arsiya and Harees were within the medium GI category (59.5 to 62.9). Similarly, the white rice showed the highest glycemic load value (20.9), whereas the other three rice dishes were within the medium GL category (10.7 to 16.7). The Arsiya and Harees were within low GL category (5.4 to 6.2). The method of cooking appears to affect the proximate composition, starch gelatinization, release of glucose and glycemic index of these dishes. We are reporting for the first time the GI and GL values of these Omani dishes. The results will help in developing appropriate dietary management strategies in meal planning by using the concept of GI and GL for both the normal and diabetic subjects to reduce their risk of chronic diseases.

***Keywords*:** glycemic index, glycemic load, cooking method, Omani rice-dishes, Arsiya, Harees

1. Introduction

Rice (Oryza sativa) is one of the most important cereal grains. It is widely consumed as a staple food since centuries by majority of the world's population and significantly contributes to food security [1-2]. The global production of rice is estimated to be about 743 million metric tons per year and China, India, Indonesia, and Bangladesh are the major producers. The global per capita consumption of rice has increased from 50 to 65 kilograms per annum over the last 3 decades. The current global consumption of milled rice is estimated to be around 510 million metric tons that is mainly consumed in Asia with the highest consumption in China [3]. In some of the Asian countries roughly 75% of their daily energy intake comes from rice dishes. In addition to a main source of carbohydrates and daily energy intake, it is estimated that cooked white rice (CWR) acts as a supplier of almost 20% of daily protein intake and many essential nutrients for a large segment of global population [4]. Previously the people were consuming partially milled

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rice that had a greater nutritional value because of the presence of higher amounts of fiber and other micronutrients and bioactive components like vitamin E, γ-oryzanol, polyphenols than the fully milled white rice [5]. Rice has relatively lower protein content as compared to other cereals such as wheat and corn with L-lysine as the first limiting amino acid [6-7]. Despite its low lysine content, the metabolic availability of L-lysine from cooked white rice (CWR) has been shown to be high if it is not cooked to the browning stage [8]. The two main starch components of rice are amylose and amylopectin. It also contains some quantities of resistant starch (RS). The amylose affects its cooking quality and the release of glucose upon digestion whereas the RS displays the prebiotic properties. Digestion of rice varies on the intrinsic properties of variety, parboiling steaming time and cooking practices [9]. Cooling of cooked white rice for 24 hours at 4 °C showed an increase in its RS content and lowered its glycemic response as compared to freshly cooked [10]. For the development of rice-based low GI meals, it is therefore important to understand the gelatinization process of starch during cooking, cooling, reheating, and its hydrolysis during digestion as well as the subsequent release and absorption of glucose into blood stream [11-12].

Glycemic Index (GI) is a numeric physiological classification of carbohydrate rich foods based on their glycemic responses during the postprandial period [13-14]. The data indicate that GI values of foods play a crucial role in meal planning to prevent the risk of chronic diseases [15]. The people do not usually eat single food, but meals based on different foods and even sometimes mix several meals. The GI of the mixed meals is affected by its constituent nutrients and their glycemic response is proportionately influenced by the amount of each nutrient present in the mixed meal. Consuming rice together with chicken, oil or vegetables influences its glycaemic and insulinaemic responses as compared to when it is eaten alone as a single food and demands variable insulin release [16]. The postprandial glucose response (PPGR) of mixed meals containing different amounts of macronutrients can differ and therefore consuming various amounts of macronutrients has been suggested to be helpful in regulating the PPGR and developing low GI and GL meals [17-18]. It has been reported that the Asians show higher glycaemic and insulinemic responses than Caucasians, which can incite them to an increased risk of type 2 diabetes mellitus (T2DM) [19]. A number of traditional rice-based dishes are prepared and commonly consumed worldwide as part of the daily diet. The data from the epidemiologic studies show that higher rice consumption may increase the risk of certain chronic disorders like type 2 diabetes [1]. Although the risk of disease may vary regionally, it has been estimated that the increased consumption of white rice may lead to 20 increased risk of type 2 diabetes [20]. Reducing the intake of high GI meals may be a tactical method in reducing hyperglycemia and increasing fat oxidation in Asians consuming high carbohydrate diets [21]. As the rice variety (Jasmine rice and Basmati) and ethnicity of people variably affect the glycemic and insulinemic responses, Tan et al. proposed that the glycemic index and insulinemic index of rice can be of clinical use in the prevention and management of diabetes [19]. Several worldwide conducted studies have evaluated the digestibility, glycemic index and insulinemic index of different types of rice-based dishes [16, 19, 22-27]. Shobana et al. reported that the glycemic index of 3 commonly consumed Indian rice varieties (Sona Masuri, Ponni and Surti Kolam) did not differ significantly [23]. They suggested that the other commonly consumed rice varieties should also be tested for their glycaemic index (GI) values. Brown rice has been reported to have a lower GI value as compared to white rice and produced low to moderate impact on body weight reduction and increase in the HDL-cholesterol level as compared to white rice. However, further long-term randomized control trials (RCTs) are required to investigate the effects of brown-rice-based diets on the glycemic control in diabetic patients [28]. Hajifaraji et al. evaluated the glycemic index of 3 commonly consumed dishes of Iran. They reported that the glycemic index of pasta made from the common wheat or semolina (durum wheat) was less than that of cooked rice and white bread [29]. Al Dhaheri et al. reported the glycaemic index (GI) and glycaemic load (GL) values of some commonly consumed breads and rice-containing dishes from the United Arab Emirates (UAE) with the aim of providing guidelines in meal planning for the Emirati population [30]. We earlier reported the nutritional quality and glycemic index of some Omani date varieties, traditional Omani breads, different types of Omani Halwa, and commonly consumed Omani snack foods [31-34]. However, no such information is available on the proximate composition, glycemic index, and glycemic load values of commonly consumed Omani rice dishes and two traditional dishes (Arsiya and Harees) in Oman. The aim of this study was therefore to evaluate the proximate composition, glycemic index, and glycemic load of these traditional rice-based Omani dishes.

2. Materials and methods

Representative samples of four different types of rice dishes (White rice, Brown rice, Kabuli rice, and Biryani rice) and two traditional Omani dishes (Arsiya and Harees) were collected from the local restaurants in Muscat and Sultan Qaboos University (SQU) Faculty Club restaurant. Only the rice portion of these rice dishes was analyzed for their proximate composition, glycemic index, and glycemic load values. The Arsiya (rice + meat) and Harees (wheat + meat) are the Omani traditional dishes, which are commonly consumed in the Middle East and are prepared with either meat or chicken as the main ingredient. Rice is added to Arsiya, whereas wheat is added to Harees as one of the recipe ingredients [35]. These traditional dishes (Arsiya and Harees) were analyzed as a whole dish on as such basis. The proximate composition (moisture, crude protein, fat, crude fiber, ash and nitrogen-free extract) of these dishes was determined according to the methods of Association of Official Analytical Chemists (AOAC) [36]. For the determination of glycemic index of these dishes ten healthy human volunteers were recruited from the student's community. The average age, weight, height, and body mass index (BMI) of volunteers were 23 ± 3.3 years, 47.8 ± 5.9 kg, 1.54 ± 0.09 m, and 20.1 ± 3.6 kg/m^2, respectively. The volunteers had normal fasting blood glucose values and an oral glucose tolerance test was performed according to American Diabetes Association (ADA) to rule out the diabetes [37]. The study was approved by the Medical Ethics Committee of Sultan Qaboos University and a written consent was obtained from the volunteers. The glycemic index was determined according to the methods as described by Wolever et al. [14] and FAO/WHO [38]. Portions of test foods and reference food (glucose) containing 50 g of available carbohydrates were given to the subjects in a random order on separate occasions after an overnight fast of ≥ 10 hours. A standard drink of water (200 mL) was given with each test food on separate occasions. Pure glucose (Dextrose monohydrate glucose powder, D-glucose) was used as a reference food. The test for the reference food (dextrose glucose powder) was repeated thrice, at the beginning, middle and the end of the study. The test was conducted at the Nutrition laboratory, Department of Food Science and Nutrition, College of Agricultural and Marine Sciences, Sultan Qaboos University, Muscat, Oman. The test started at 8:30 am. A two-day break period was given between the testing of each food and test food. The blood samples were taken by capillary finger prick method at 0 (fasting), 15, 30, 45, 60, 90 and 120 minutes after the intake of test foods. The On Call EZII Blood Glucose Monitoring System was used to measure the blood glucose levels that utilizes a dry reagent technology based on the glucose oxidase method (www.aconlabs.com) [39-40]. A small drop of capillary blood was applied to the tip of the On Call Plus test-strip already inserted in the glucometer and the blood glucose value was noted. The incremental area under the curve (iAUC) was calculated and the GI value was determined as: Glycemic Index = (iAUC test food/iAUC standard reference food) × 100. The glycemic load was calculated as: Glycemic Load (GL) = GI × available carbohydrate (g) per serving/100 [41]. The serving size was determined as described in our previous publication depending upon the usual Omani dietary consumption patterns [35]. Statistical analysis of the data was carried out with the help of software Statistical Package for Social Sciences (SPSS) v.16. The data were subjected to statistical analysis using one way analysis of variance (ANOVA) and the P-value of < 0.05 was considered as statistically significant [42].

3. Results and discussion

Data on the proximate composition of these Omani dishes are given in Table 1. The moisture, crude protein, total fat, crude fiber, ash, and nitrogen free extract (NFE) contents of the rice portion of Omani rice dishes (White rice, Brown rice, Kabuli rice, Biryani rice) ranged between 60.9 to 67.1, 2.5 to 3.6, 1.1 to 3.9, 0.7 to 1.0, 0.4 to 1.0, and 28.2 to 30.0 (g per 100 g on as such basis), respectively, whereas the energy values ranged between 133 to 169 kcal/100 g (Table 1). The proximate composition of Omani rice dishes as well as of Arsiya and Harees differed significantly ($P < 0.05$). The serving sizes, amount of carbohydrates (g per serving), glycemic index and glycemic load values of rice-based Omani dishes as well as of Arsiya and Harees are given in Table 2. The glycemic index and glycemic load values of all these dishes differed significantly ($P < 0.05$) (Table 2). The glycemic index and glycemic load of Kabuli rice and Biryani rice were significantly lower than the other 2 types of rice dishes (white and brown rice). This may be due to the cooking method and dish composition. The results indicated that with the exception of white rice, which showed a high glycemic index value (77.3), all other rice dishes as well as Arsiya and Harees were within the medium glycemic index category (59.5 to 62.9). Similarly, the glycemic load of the white rice (20.9) was in the high glycemic load category

[43-44]. Whereas all other rice dishes (brown rice, Kabuli rice, and Biryani rice) were in the medium glycemic load category [44]. The traditional Omani dishes (Arsiya and Harees) were in the low glycemic load category (Table 2). The results indicated that the ingredient composition and method of cooking may be responsible for the variability in their proximate composition, glycemic index, and glycemic load values of these Omani dishes.

Table 1. Proximate composition of different types of Omani rice and other dishes (mean ± SEM)

Food	Moisture g/100 g	Crude protein g/100 g	Total fat g/100 g	Crude fiber g/100 g	Ash g/100 g	Nitrogen free extract (NFE) g/100 g	Gross Energy kcal/100 g*
White rice	67.1 ± 0.7	2.5 ± 0.7	1.1 ± 0.1	0.7 ± 0.1	0.4 ± 0.2	28.2 ± 1.9	132.7 ± 2.9^{d}
Brown rice	62.3 ± 0.9	2.9 ± 0.8	1.3 ± 0.4	0.9 ± 0.2	0.7 ± 0.1	31.9 ± 2.5	150.9 ± 2.6^{c}
Kabuli rice	60.9 ± 1.2	3.4 ± 0.5	3.9 ± 0.7	1.0 ± 0.1	0.8 ± 0.2	30.0 ± 2.4	168.7 ± 3.1^{a}
Biryani rice	62.5 ± 1.3	3.6 ± 0.9	3.3 ± 0.9	0.9 ± 0.4	1.0 ± 0.3	28.7 ± 1.8	158.9 ± 1.9^{b}
Arsiya with chicken	81.5 ± 2.2	4.2 ± 0.7	1.8 ± 0.5	1.1 ± 0.1	0.6 ± 0.2	10.8 ± 1.2	76.2 ± 1.5^{e}
Harees with chicken	82.7 ± 1.8	3.9 ± 0.9	1.4 ± 0.4	1.6 ± 0.4	0.8 ± 0.3	9.6 ± 1.3	66.6 ± 1.3^{f}

*Different alphabets in the same column means significantly different at P < 0.05.

Table 2. Glycemic Index and glycemic Load of different Omani rice dishes (mean ± SEM)

Food Items	Serving Size	Carbohydrates per serving (g)	Glycemic Index*	Glycemic Load*
White rice	½ cup (100 g)	27	77.3 ± 3.5^{a}	20.9 ± 1.3^{a}
Brown rice	½ cup (100 g)	27	61.8 ± 3.1^{b}	16.7 ± 1.5^{b}
Kabuli rice	½ cup (100 g)	18	59.5 ± 2.7^{b}	10.7 ± 1.3^{c}
Biryani rice	½ cup (100 g)	17	62.9 ± 2.5^{b}	10.7 ± 1.2^{c}
Arsiya with chicken	½ cup (80 g)	10	61.8 ± 2.9^{b}	6.2 ± 0.9^{d}
Harees with chicken	½ cup (80 g)	9	59.6 ± 2.9^{b}	5.4 ± 0.8^{d}

*Different alphabets in the same column means significantly different at P < 0.05.

The method of cooking has been shown to differentially affect the starch gelatinization process in rice, which may subsequently affect the digestion of starch and release of glucose into the blood stream. It has been shown that foods cooked by different methods can have significantly different rates of digestion and absorption and hence can result in different GI values [16, 45-46]. Rice cooked at higher temperature (90 °C) showed lower peak viscosity and breakdown in pasting properties, as compared to that cooked at lower temperature (82 °C). Cooking at 82 °C with 1.9-fold water volume was considered optimal to produce lower GI instant rice [47]. Sonia and colleagues (2015) reported that when cooked white rice was cooled for 24 hours at 4 degrees centigrade (°C) and then reheated it showed lower glycemic response as compared to freshly cooked white rice. They attributed it to its increased resistant starch content during the cooling of rice [10]. The quality of rice is also affected by it starch components amylose and amylopectin. Understanding the gelatinization of starch and its hydrolysis during the digestion process, with subsequent release of glucose, is important for the development of rice-based recipes with a lower GI value [11]. This is the reason why different types of rice dishes showed variable glycemic responses and as a result had a different glycemic index and glycemic load values. Stir-frying white rice with fat or oil increased its resistant starch content and helped in reducing the postprandial glycemic responses. Rice-dishes (such as rice biryani, rice Kabuli, rice pulao, stir-fried white rice) prepared in different ways with added fat, meat, vegetables etc. may not only add taste to it but can also be helpful in reducing its glycemic responses [48]. The results of the present study are in line with the results reported in previous studies from different parts of the world [23-25, 49]. Our results also validate the findings of Abdul Rahim et al., who reported that brown rice had a lower GI value as compared to white rice [28]. Osman et al. showed that the GI values of rice-based mixed meals can be predicted or estimated using the regression equations as the values calculated through the prediction formula were found to be similar to the measured GI values in human volunteers [49].

Rice is the staple food for majority of the global population and is the main contributor of carbohydrates and energy in their daily diet. It is generally categorized as a high glycemic index food as after its ingestion and digestion, the glucose is immediately absorbed by the body and released into the blood stream. It is therefore considered as unsuitable for consumption by obese and diabetic people [20, 50-51]. However, rice is generally consumed with other foods, like pulses, vegetables, meat, or fish, which may affect the hydrolysis of rice starch and slow down the release of glucose. Sun et al. showed that the glycaemic index (GI) of pure white rice was found to be 96, whereas when consumed mixed with chicken breast, ground nut oil and vegetables, it was reduced to 50 [16]. The appropriate cooking method as well as the consumption of other foods and nutrients, like fat and protein together with rice in mixed meals, has therefore been suggested as a way to reduce the glycemic index of rice-based meals [12, 16]. It has therefore been suggested that the development of instant rice products with lower GI values will be helpful to a wider range of population, particularly for the obese and diabetic people [47]. The data on the GI and GL values of commonly consumed Omani rice dishes as well as of Arsiya and Harees has been reported for the first time and will be very helpful in the daily meal planning for both the normal people and diabetic patients. There is a need to prepare a comprehensive compendium on the glycemic index and glycemic load values of the traditional Middle Eastern and Asian foods. This is important in dietary meal planning using the glycemic index concept of foods to reduce the risk of chronic diseases. Further studies should therefore be conducted to evaluate the glycemic index and glycemic load values of all other traditional Omani foods and dishes.

4. Conclusion

Significant differences were observed in the proximate composition, GI, and GL values of 4 different types of Omani rice dishes. The glycemic index and glycemic load of Kabuli rice and Biryani rice was significantly lower than other 2 types of rice dishes (white and brown rice). This may be due to cooking method and dish composition. The results indicated that method of cooking as well as the dish composition can affect the gelatinization of rice starch and may subsequently the chemical composition and glycemic index and glycemic load of these dishes. Further studies should therefore be conducted to evaluate the glycemic index and glycemic load of all other traditional Omani foods. The results of this study are a valuable addition to the nutritional database for Omani foods and will help in developing the appropriate dietary management strategies utilizing the concept of GI of foods for incorporating these rice dishes in daily meal planning for normal and diabetic subjects to reduce their risk of chronic diseases.

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Conflict of interest

There is no conflict of interest.

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