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Glycemic indices, glycemic load and glycemic response for seventeen varieties of dates grown in Saudi Arabia

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BACKGROUND: Dates are consumed worldwide, and are an important fruit for many individuals in Saudi Arabia. Currently, limited information is available on the glycemic indices of different date varieties.
OBJECTIVES: To determine the glycemic index (GI), glycemic load (GL) and glycemic response for 17 common date varieties in Saudi Arabia.
DESIGN: Prospective clinical trial on healthy subjects.
SETTING: College of Medicine, Qassim University, Buraydah, Saudi Arabia.
PATIENTS AND METHODS: The available carbohydrate content of *Tamer* stage dates was determined using standard laboratory methods. Healthy subjects (ten males and nine females) received 50 g of glucose (on three separate occasions) and 50 g equivalent of available carbohydrates from the seventeen varieties of date (each once). The GI and GL were then calculated.
MAIN OUTCOME MEASURE(S): GI, GL, and glycemic response.
RESULTS: The mean (SEM) GI of the date samples was 55.2 (7.7) (range, 42.8–74.6). *Sellaj* and *Maktoomi* exhibited the highest GI (74.6 [10.1] and 71.0 [11.1]), respectively, whereas *Shaqra, Sukkary,* and *Sag'ai* had the lowest GI (42.8 [5.5], 43.4 [4.7] and 44.6 [6]), respectively. The GL of the date samples ranged from 8.5 to 24. *Sellaj* had a high GL (24), whereas *Ajwah* and *Shaqra* had a low GL (8.5 and 9.2). The analyses suggested no significant difference in GI between the date varieties. However, the GL values differed significantly between the 17 date varieties ($P<.001$).
CONCLUSION: The results provide reliable GI and GL values for 17 common date varieties in Saudi Arabia. The identification of date varieties with lower glycemic responses may help lower the GI of the diet of both healthy and diabetic Saudi individuals.
LIMITATIONS: We used dates at the *Tamer* stage, which may not be translatable to all types of dates.

The date palm (*Phoenix dactylifera* L.) is one of the oldest cultivated plants worldwide, and has been used as food for over 6000 years.[1] It has been closely linked to the daily lives of people in the Middle East, including Saudi Arabia, since ancient times. There are more than 200 date varieties available worldwide.[2] Today, Saudi Arabia is the second largest producer of dates in the world, with more than one million tons produced per year. Al-Qassim province is one of the most important producers of dates in Saudi Arabia, with more than six million fruitful date palms as well as the largest date market in the world. It achieves annual sales of up to 1.5 billion Saudi riyals in 75 days.[3]

Dates are an essential high-energy food in the Saudi diet. In addition to providing important nutrients, dates and their constituents play a role in disease prevention via their anti-oxidative, anti-inflammatory, and anti-bacterial actions.[4–8] Dates pass a number of stages during development. The final maturation stage, called "*Tamer* stage," is when the date has dried to a fairly firm consistency and is a darker color.[5]

Dates have important roles in certain religions. For example, in Islam the day long fast that occurs during Ramadan is often broken using dates.[5] In addition, the numerous health benefits of dates, including their nutritional significance, are described in the Qur'an (Koran). Furthermore, the Prophet Muhammad stated that the date palm had the greatest benefits, and suggest that Muslims should eat dates because they can cure many disorders.[9]

Novel dietary management strategies and methods are needed urgently to control various diseases. The high consumption of dates in these traditional cultures raises the question of whether the general population and particularly diabetic patients should eat dates in the same manner as their forefathers. However, the answer to this is unclear since few reports have described the glycemic response to date consumption.

In nutrition, the concept of glycemic indices (GIs) was introduced to classify foods (particularly those rich in carbohydrates) according to the postprandial changes in blood glucose that occurs after consumption.[10] The rate at which glucose enters the blood and the length of time that blood glucose levels are elevated affect the magnitude of a number of metabolic and hormonal changes that can modulate many disease- and health-related and parameters. Low-GI foods can reduce several risk factors for chronic, non-communicable diseases.[11–16] In addition, a previous study suggested that the GI of individual food items can be used to make healthier eating choices when designing meals.[17] A GI value describes the glycemic response to isoglucidic foods; therefore, the GI does not always truly represent the glycemic effects elicited by an individual serving of different types of food.[18] Because of this, the glycemic load (GL) concept was introduced as a means of determining the overall glycemic effects of standard food portions.[19] It is usually important to consider the effects of both GI and GL, particularly in foods that contain low levels of carbohydrate.

Currently, very limited, inconsistent, and contradictory information is available on the glycemic response, GI, and GL values of different date varieties, which could be attributed to both different food types and methodological variation.[20–23] A number of factors can affect the chemical composition of dates, including the agricultural methods used and soil conditions during cultivation, the ripening stage, and the cultivar.[24] Therefore, it is important to understand the GI and chemical composition of different local and regional date varieties. Because of this, the aim of the current study was to estimate the GI of different date varieties grown in Saudi Arabia, specifically in Al-Qassim province. This information will be useful for health professionals when formulating nutritional guidelines and dietary recommendations.

PATIENTS AND METHODS

Healthy participants were recruited from the local Qassim population using advertisements and personal communication. Before being enrolled in the study, all potential participants were briefed on all aspects of the experiment and were given the opportunity to ask questions. After providing written informed consent, a health assessment was performed, which included measuring blood pressure, height, weight, body mass index (BMI), waist circumference, and body fat composition. All participants were healthy, free from any clinical signs or symptoms of chronic diseases, and did not use any medications. They had normal fasting blood glucose levels and oral glucose tolerance test results to rule out diabetes.[25] Exclusion criteria included a BMI >35 kg/m^2, any alcohol intake, smoking, pregnancy, a family or personal history of psychiatric disorders, epilepsy, sleep disorders, food allergies, the use of any medications, alimentary tract surgery, and a history of gastroenteritis in the previous 6 months. Subjects were also excluded if they had diabetes, gastroenterological disorders, chronic diseases (such as bronchial asthma or rheumatoid arthritis), or acute illness (such as upper respiratory tract or urinary tract infection). BMI was calculated using the formula: weight (kg)/height in (m^2). The amount of body fat was determined using a body composition analyzer (HBF-514C; Omron, Netherland).

Seventeen different date varieties at the *Tamer* stage were tested: 16 were grown in Al-Qassim, and one (*Ajwah*) was the most popular type in Al-Madinah Al-Munawarah. Because changes in environmental factors (humidity and the type of irrigation system, fertilization and soil used during cultivation) can affect the chemical characteristics of dates, samples were collected and pooled from different locations within each region. Mature fruits of uniform size that were free of physical damage, injury from insects, and fungal infestation were selected for the study.

Fresh fruit (about 1 g date fruit) was homogenized in 40 mL of ethanol: water (80% v/v) extraction solution. The mixture was sonicated for 15 min at 60°C and cooled at room temperature. The solution was then increased to 50 mL total volume with extraction solution and filtered through a 0.42 μm filter. A chromatographic analyses was done in a Shimadzu High-Performance Liquid Chromatography (LC-20) machine equipped with a double pump, a manual injector with a 100 μL loop, a RID-6A Shimadzu refractive index detector and a C-R6A chromatopac integrator. Chromatographic separation was achieved with a tracer carbohydrates column (5 μm particle size; 250 mm × 4.6 mm i.d.), and an NH2 precolumn (13 mm×3 mm i.d.), both from tracer

(Teknokroma, Barcelona, Spain). Chromatographic separation was undertake with an isocratic elution mobile phase of acetonitrile–water (75:25, v/v) and degassed before use (Chavez-Servin et al, 2004). The flow-rate of this eluent is 1.8 mL/min and the volume of the sample injected was 20 µL. Column temperature maintained at 25°C. Peaks were identified by comparing retention times with sugar standards. The respective peak areas were used for the quantitative analysis. Calibration curves for each sugar were prepared at seven levels, from 0.5 to 10 mg/mL for fructose and glucose, and sucrose. Concentrations of each sugar type and total available sugar contents, as g/100 g fresh fruit, were calculated.[26]

A qualified technician performed all blood glucose measurements. Blood was obtained from a finger prick using a sterile and disposable lancing device. Glucose levels were measured using OneTouch Select Lifescan glucometers (LifeScan, Inc.), which were tested for accuracy and precision using the provided kits with a Quo-Lab, EKF diagnostic (Quotient Diagnostics Ltd. Walton-on-Thames, Surrey, UK) and the glucose oxidase method. Recent reports have suggested that capillary rather than venous blood sampling is preferred for reliable GI testing.[17,27] To minimize plasma dilution, fingertips were not squeezed to extract blood. The first drop of expressed blood was discarded, and the subsequent drop was used for testing. The study was approved by institutional review board of the College of Medicine, Qassim University.

The study protocol was adopted from that described by Brouns et al,[17] and is consistent with procedures recommended by the FAO/WHO for glycemic response studies.[28] According to these guidelines, the GI of a food should be determined using tests repeated in six or more subjects, but 10 subjects provide a higher degree of power and precision.[17] Thus, each test food was analyzed using at least 10 subjects. Ten was chosen based on published studies where similar numbers had provided adequate power.[17,22,29,30] GI testing was carried out in the morning after an overnight fast of 10 hours on separate occasions; each test was separated from the next by at least one "washout" day. Subjects were blinded to the type of the date that they consumed. Portions of the test food and standard reference food containing 50 g available carbohydrates were given to the subjects in a random order. The reference food contained 50 g of glucose dissolved in 250 mL water (Glutol-50, Saudi Medical Solution Co., Riyadh, Saudi Arabia), and was tested on three alternating days (at the beginning, middle, and end of the experiment) to minimize day-to-day variations in glucose tolerance. The dates were weighed using an H110 Sartor analytical scale (Sartorius AG, Goettingen, Germany). They were consumed by all participants with 250 mL of water and finished within 12 min. Blood samples for glucose analysis were taken at 0 (fasting), 15, 30, 45, 60, 90, and 120 minutes following the start of the meal. Participants were advised to minimize physical activity during testing and remain seated.

The total blood glucose response was expressed as the incremental area under the blood glucose response curve (IAUC), ignoring the area below baseline, and was calculated according to the methods described by Wolever et al (1991) and FAO/WHO (1998).[28,30] The means, standard deviations, and coefficient of variation of the IAUC were calculated for each subject's repeated reference food. The IAUC of all test foods eaten by each subject was expressed as a percentage of the mean IAUC of the reference food eaten by the same subject. The GI values were calculated as:

GI=(IAUC test food/IAUC standard reference food) ×100

The mean of the values for all subjects was used to calculate the GI for each type of date.

The GL of a serving of each food was calculated as follows:

GL=(GI of the test food × carbohydrate content of a serving of the test food [g])/100

A serving size of each test date was defined as three average-sized dates.

Data were analyzed using Microsoft Excel 2016 and SPSS version 23 (SPSS Inc., Chicago, IL, USA). GI values >2 SD above the mean were considered outliers and were excluded. GI was measured for each date meal by calculating the area under the curve using an Excel spreadsheet kindly provided by Prof. Thomas Wolever from the University of Toronto-Canada. The data are presented as means and standard deviations (SD) or standard errors of the mean (SEM). Since the values are continuous, the glycemic index and glycemic load of the different date varieties were compared using two-way ANOVA (analysis of variance). The two factors were participant and date variety.

RESULTS

Nineteen subjects (nine females and ten males) were used to calculate the GI of the different date varieties. The subjects had a mean (SD) age of 31.2 (4.8) years and BMI of 27.5 (6.1) kg/m^2. The mean body fat was 32.7 (13.2%). The mean fasting blood glucose concentration was 82.4 (7.3) mg/dL, and mean HbA1c was 4.8 (0.2). All parameters were within the normal range. The blood glucose tolerance tests were also within the normal range for all volunteers (**Table 1**).

The glycemic response curves for the standard food (glucose) and various date samples are shown in **Figures 1 and 2**. With the exception of Sellaj, *Um-Kabar,* and *Osillah*, all dates attained peak postprandial blood glucose levels after 30 min of ingestion and decreased thereafter. *Sellaj, Um-Kabar,* and *Osillah* resulted in a peak postprandial blood glucose value after 15 minutes, and then showed a similar trend as the other varieties (**Figure 1 and 2**).

The mean (SEM) GI of date samples was 55.2 (7.7) (range, 42.8–74.6). *Sellaj* and *Maktoomi* had the highest GI (74.6 [10.1] and 71.0 [11.1]), respectively, whereas Shaqra, *Sukkary,* and *Sag'ai* exhibited the lowest GI

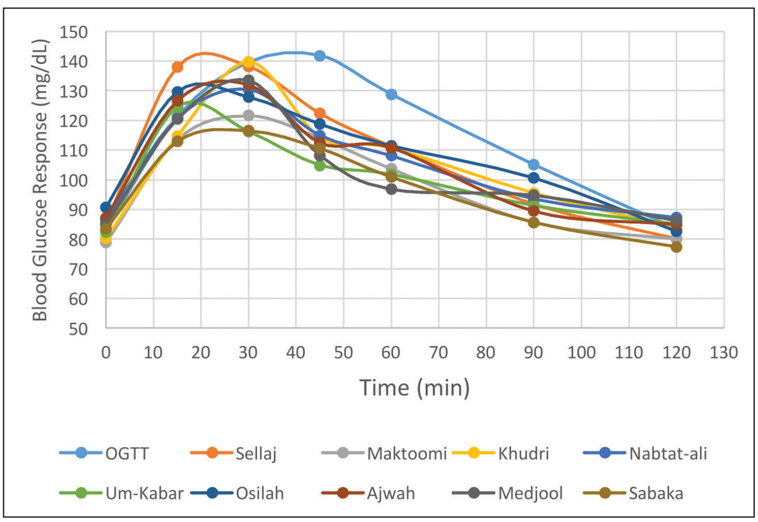

Figure 1. Average glucose response of the subjects on different dates varieties.

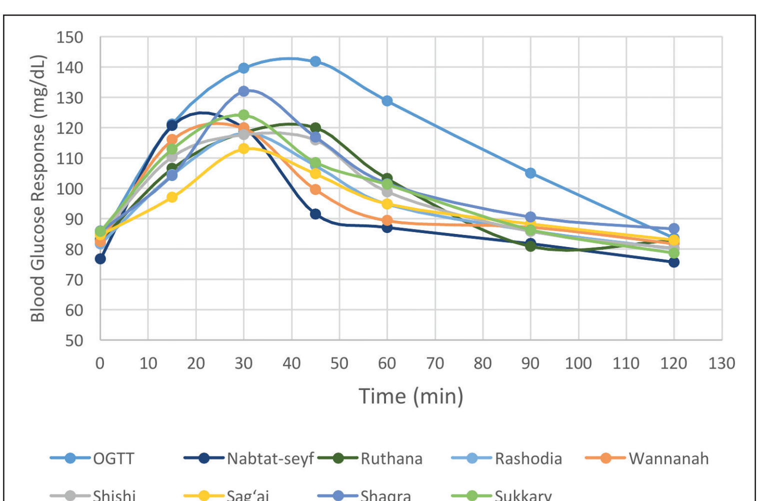

Figure 2. Average glucose response of the subjects on different dates varieties.

Table 1. Baseline characteristics of the study subjects.

Variable	mean (SD)
Age (years)	31.2 (4.8)
Weight (kg)	71.7 (15.2)
Height (cm)	162 (8.2)
BMI (kg/m^2)	27.5 (6.1)
Waist circumference (cm)	88.1 (13.9)
BP systolic (mm Hg)	105.1 (12.8)
BP diastolic (mm Hg)	66.9 (5.1)
Body fat (%)	32.7 (13.2)
FBG (inches)	82.4 (7.3)
HbA1c (years)	4.8 (0.2)

(42.8 [5.5], 43.4 [4.7] and 44.6 [6]), respectively. The GL of the date samples ranged from 8.5 to 24. Sellaj was high GL (24), whereas *Ajwah* and *Shaqra* were low GL (8.5 and 9.2). **Table 2** shows the GI and GL results for the 17 date varieties. There was no significant difference in glycemic index between the date varieties. However, the glycemic load values were found to significantly differ between the 17 date varieties (P<.001). The consumption of the 17 date varieties did not cause significant postprandial glucose excursions.

DISCUSSION

Dates are the main fruit in Saudi Arabia; they are widely consumed there and in most other Islamic countries. They are one of the most significant commercial crops and have also been documented in the Holy Quran and modern scientific literature. However, there is little information available about GI and GL of different date varieties. In the present study, we used standard methods to determine the glycemic values of 17 popular date varieties in Saudi Arabia. For practical applications, GIs are often grouped into low (<55), medium (56–69), or high (≥70) glycemic response categories.31 A similar GL classification system is used, in which foods are categorized as having low (≤10), medium (10–20) or high GL (≥20).[32]

Previous studies revealed that GIs vary among different date varieties: the mean range of GIs for *Khalas, Barhi*, and *Bo ma'an* were 30.5–49.[7,22] whereas those of three varieties collected from various regions in Oman was 47.6–57.7.[33] Lock et al performed a study in pregnant women, and reported that a date had a GI of 61.6. In the UAE, Alkaabi et al assessed the GIs of five varieties of dates and reported a range of 46.3–55.1.[23] Finally, international tables suggest that the mean GI±SEM for dates is 42 (4).[34] Consistent with these previous observations, the range of GIs calculated in this study was 42.8–74.6, which classifies dates as low-to-high food items (mostly low GI items) depending on their type (**Table 2**). There were no significant differences in the GIs of different date varieties. The differences in the GI of the date varieties could be attributed to the type of date and variation in the methods used.

The GL is a useful measure of the true glycemic response because it considers portion size. Although both a higher GI and GL suggest that a food could cause a significant increase in blood glucose levels, GL considers realistic portion sizes and so could be more accurate.[16] The relationship between the GI and GL of a food is complex, because small quantities of a food with a high GI food could have a low GL, whereas a food with a low GI might have a high GL. For example, an individual portion of the low GI date *Sag'ai* has the same GL as a portion of *Maktoomi*, which has a high GI. However, this is not always accurate since a comparison of individual portions of *Sag'ai* and *Osilah* suggested that *Sag'ai*, which has the lowest GI of the two varieties, has the higher GL. In the current study, an individual serving size of each date variety was defined as three normal, average-sized dates. Although the GI of all foods is fixed, any individual food item could have a low, medium, or high GL depending on the size of the portion eaten. Additionally, the glycemic load values in this study were found to significantly differ between the 17 date varieties ($P<.001$). The highest values were found in the *Sellaj* and *Um-Kabar* varieties, whilst the lowest values were found in the *Ajwah* and *Shaqra* varieties.

The prevalence of diabetes and particularly type 2 diabetes is very high in Saudi Arabia; it is among the highest in Arab countries and also worldwide.[35,36] Therefore, it is important to determine whether dates should be considered a healthy food choice in these individuals. The current study demonstrated that date consumption did not cause significant fluctuations in the glycemic response or a rapid elevation

Table 2. Numbers of subjects tested, weights of meals consumed, and mean glycemic index results.

Dates	Number of subjects	% of carbohydrates per dates	Weight consumed (g)	Glycemic Index (SEM)[a]	Glycemic load[b]
Sellaj	9	72.5	68.96	74.6 (10.1)	24
Maktoomi	10	72.98	68.51	71.0 (11.1)	16.1
Khudri	10	74.56	67.06	61.7 (7.4)	14.2
Nabtat-ali	10	72.18	69.27	59.9 (6.9)	16.3
Um-Kabar	10	72.34	69.11	58.7 (7.3)	22
Osilah	9	60.62	82.48	56.6 (12.1)	13.1
Ajwah	10	71.29	70.13	55.9 (5.9)	8.5
Medjool	10	70.88	70.54	55.3 (6.8)	17.2
Sabaka	10	71.92	69.52	54.9 (11.5)	11.8
Nabtat-seyf	9	74.67	66.96	54.4 (10.3)	11.8
Ruthana	10	68.08	73.44	52.5 (4)	11.7
Rashodia	10	74.32	67.27	50.9 (6.5)	12.4
Wannanah	10	74.02	67.54	50.9 (7.3)	12.4
Shishi	10	69.62	71.81	50.2 (7.2)	12.3
Sag'ai	9	68.79	72.68	44.6 (6)	15.6
Sukkary	10	64.4	77.63	43.4 (4.7)	11.7
Shaqra	10	74.71	66.92	42.8 (5.5)	9.2

[a]No significant differences by ANOVA. [b]$P<.001$ by ANOVA. Differences were between the *Sellaj* and *Um-Kabar* varieties, while the lowest values were in the *Ajwah* and *Shaqra* varieties.

in blood glucose concentrations (**Figures 1 and 2**). The American Diabetic Association (2014) stated the primary goal in the management of diabetes should be to regulate blood glucose levels to achieve near-normal concentrations. Therefore, dietary choices with minimal post-prandial hyperglycemic effects are important to limit diabetic complications.[37] The European guidelines on the use of GI state that the consumption of carbohydrate-rich foods with low-GIs is acceptable, as long as other they are consumed with appropriate foods.[38] Previous randomized controlled trials revealed that the consumption of a low-GI diet improved glycemic control in patients with diabetes.[39] Furthermore, a low-GI diet was reported to decrease the risk of diseases such as breast cancer, coronary heart disease, and gallbladder disease. It might also improve health-related markers such as HbA1c levels, blood lipid profiles, and body weight.[14,40–43] The current study revealed that dates have low-to-medium GI values (**Table 2**). Therefore, they could be a suitable carbohydrate source in both normal and diabetic individuals.

CONCLUSION

The current study presented data that provide GI and GL of 17 different date varieties grown in Saudi Arabia. Identifying different dates varieties that elicit reduced glycemic responses could help reduce the overall GI of the diet of many individuals in Saudi Arabia, which could in turn promote the prevention and management of chronic conditions including diabetes and obesity. Nevertheless, further studies are required to compare the nutritional and metabolic characteristics of fresh and sun-dried date varieties, as well as other date products available on the market.

Limitations of the study were that the test meals were not randomized, and glucose levels should have been taken before, halfway through, and at the end of the test meals in an ideal experiment. In addition, we used dates at the *Tamer* stage, and so the conclusions from this study may not be translatable to all types of date.

Disclosure

The authors have no conflict of interest to declare. The study was not supported or funded by any commercial interest.

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