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RESEARCH ARTICLE

Glycemic index (GI) and glycemic load (GL) values for dried *bisr* and *tamr* dates

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ABSTRACT

Background: Date fruits can be consumed at different stages of maturity and thus might vary in glycemic response. Therefore, this study aims to evaluate the nutritional composition, glycemic index (GI) and glycemic load (GL) values of dried Bisr (mature unripe) and *Tamr* (mature ripe) dates. **Methods:** Fifteen healthy female participants (18 and 25 years), were recruited to assess the GI and GL values of dried *Bisr* and dried *Tamr* dates. Each participant was tested in three different times. Trials were separated by 1 week and proceeded in a randomized counterbalanced manner. Anthropometrics and food records were obtained for all participants.**Results:** Proximate analysis revealed significant differences between *Bisr* and *Tamr* dates in moisture, ash, fat, protein, and fiber content ($P<0.05$), whereas, carbohydrate and energy contents were comparable ($P>0.05$). The incremental area under the blood glucose response curve was higher (164.5 ± 47.8) for the standard food in comparison with dried *Bisr* (88.5 ± 24.1, $P < 0.0001$) or dried *Tamr* dates (88.2 ± 27.9, $P<0.0001$), whereas, no significant differences were detected between the test foods ($P>0.05$). Both GI (*Bisr*: 54.6 ± 15.2 vs. *Tamr*: 54.3 ± 14.3) and GL (*Bisr*: 13.65 vs. *Tamr*: 13.58) were not significantly different between the test food items ($P>0.05$). **Conclusion:** Dried date fruits induce similar glycemic responses regardless of their maturity stage.

Keywords: Glycemic index; Glycemic load; *Bisr*; Date fruits; *Tamr*

INTRODUCTION

The fruit of the date palm (*Phoenix dactylifera*, L.) is consumed worldwide and is a dietary staple for many people in the Arabic world. Dates occupy about 30% of the cultivated land in the United Arab Emirates (UAE) producing about 760,000 metric tonnes (MT) of fruit, which is about 11.3% of the world's production (Aldhaheri et al., 2004: Kamal-Eldin et al., 2012: MAF, 2000). With this vast increase in date fruit production in the UAE, processing and industrialization of date fruits to produce new value-added products is highly warranted.

Date fruits are consumed at three different stages of maturation: mature but unripe, namely *Bisr* or *Khalal* (50% moisture), ripened, namely *Rutab* (30%-35% moisture), and mature, namely *Tamr* (10%-30% moisture) (Kamal-Eldin et al., 2012). Date fruits are rich in nutrients such as carbohydrates (total sugars, 44%-88%), proteins (2.3-5.6%), fibers (6.4%-11.5%), fatty acids (0.2%-0.5%), salts, minerals, and vitamins (Alkaabi et al., 2011). Currently, a very small percentage of date fruits is consumed at the firm and crunchy *Bisr* stage, a small percentage at the *Rutab* or ripe stage, and the largest percentage is consumed as fresh or dried pitted dates at the *Tamr* stage (Degefa et al., 2017). *Bisr* dates contain more of the health-promoting dietary fiber and less sugar than *Rutab* and *Tamr* (Elleuch et al., 2011: Elleuch et al., 2008). Nevertheless, the physiological transformation from *Bisr* to *Rutab* is interrupted in a large percentage of date fruits, which are then wasted on the trees and consequently discarded or at best used as animal feed. Consequently, if they were to be valorized at the *Bisr* stage, losses of date fruits might be minimized. Moreover, some varieties that are not preferred by consumers at the *Tamr* stage might perform better at the *Bisr* stage. In addition, drying of *Bisr* dates will enable their use as additives in breakfast cereals and baked products, alone or with other fruits and/or nuts.

It is estimated that globally more than 135 million people have Type 2 diabetes mellitus (DM) with United States

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having more than 20 million diabetic people (15% of all DM patients) (Li et al., 2011). According the International Diabetes Federation (IDF), in 2015, the UAE was ranked 13th worldwide for prevalence of Type 2 DM, which is due to changes in lifestyle and dietary habits (IDF, 2015). High intake of dates (date fruits) in the UAE could be a contributing factor to the high prevalence of diabetes and obesity among UAE individuals. Despite their high sugar contents, *Tamr* dates were identified to have low glycemic load (GL) value after consumption (Alkaabi et al., 2011: Miller et al., 2003: Miller et al., 2002). Whereas, *Bisr* dates have lower levels of soluble sugars compared with *Tamr* dates, which might have an effect on their glycemic index (GI) value (Eltayeb et al., 1999). Health benefits of low GI foods with particular reference to obesity, diabetes, and cardiovascular diseases were previously highlighted (Gilbertson et al., 2001). The current study aims to evaluate the nutritional composition, GI and GL values of dried *Bisr* and dried *Tamr* dates.

EXPERIMENTAL METHODS

Subjects

All participants were recruited from United Arab Emirates University (UAEU) to voluntarily participate in the study. E-mail invitations, posters displayed in different UAEU buildings and words of mouth were used as means for subject recruitments. Fifteen healthy female participants aged between 18 and 25 years old were recruited from the female campus of the UAEU. Taking into consideration that participants' characteristics such as age, sex, body-mass index and ethnicity are not supposed to influence GI determination(Wolever et al., 2003). In addition, similar studies have been conducted on female subjects only (Amano et al., 2004: Al Dhaheri et al., 2015). Participants did not take part if they had any of the exclusion criteria, defined as: aged less than 18 or more than 25 years old; if they had their menstrual cycle; body mass index (BMI) value more than or equal to 25 kg/m^2 or less than 18.5 kg/m^2; fasting plasma glucose (FPG) value of more than 6.1 mmol/l; and having a known history of impaired glucose tolerance or DM. Participants completed a health-screening questionnaire before taking part in the study to make sure that they meet the inclusion criteria. Those who met the inclusion criteria were given complete details about the study protocol and the chance to ask questions. Informed written consent was obtained from all participants before commencement of the study protocol. In addition, participants were asked to fast for 12 hours the night before the test. The day before the GI test, participants were asked to minimize their participation in any vigorous physical activity, to limit their intake of caffeine-containing drinks, and not to smoke.

The present study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving human subjects were approved by the United Arab Emirates University Scientific Research Ethics Committee (UAEU, Reference Number - 516/09).

Anthropometric measurements

Anthropometric measurements were carried once for each participant, prior to recruitment, to confirm that the subject fit the inclusion criteria. All measurements were in a fasting state after a 12-hour fast, with subjects wearing light clothes and no shoes. Each measurement was taken three times and averaged. Measurements included height in cm using a stadiometer (Seca Stadiometer, Seca Ltd, Birmingham, UK) (Gibson, 2005), body weight in kg, fat mass (FM) and fat free mass (FFM) using the Tanita Segmental Body Composition Analyzer (Tanita BC-418 Ltd, Tanita UK) (Chang et al., 2013). BMI was calculated by dividing the weight in kg by the height in meters, squared: BMI = weight (kg)/height^2 (m^2), using the WHO definition for BMI classification (WHO, 2006).

Test foods

Dried *Bisr* and *Tamr* dates were freshly harvested from the UAE date variety Neghal, which was procured at the College of Food and Agriculture farm (Al-Foah Farm, UAEU). This date variety was selected based on its lack of bitterness at the *Bisr* stage. The *Bisr* date fruits were sorted, pitted, washed, blanched and dried. Sun-drying experiments were performed in a direct solar dryer for 7 days until the weight stopped decreasing. The initial moisture content of the fresh *Bisr* fruit was around 62%, and was reduced by drying to 6%, leading to a water activity of 0.53 in the dried samples.

Analytical methods

Proximate analyses of moisture, protein, fat, fiber and ash content were conducted at the Nutrition and Health Department laboratories of UAEU for each test food using standard analytical methods described by the Association of Official Analytical Chemists (AOAC and Horwitz, 2003). Each test was performed in triplicate and the results averaged to minimize possible systematic and random experimental errors. Carbohydrate content was estimated by subtraction of the mean percentage values of the moisture, ash, protein, fat, and crude fiber from 100 (Bouaziz et al., 2013). Total energy content was calculated by multiplying the amounts of protein, carbohydrate and fat by factors of 4, 4 and 9 respectively (Dashti et al., 2001).

Study protocol

The method used for the measurement of GI was adapted from that described by Wolever et al. (Wolever et al., 1991), and Brouns et al. (Brouns et al., 2005) and

in line with procedures recommended by the FAO/WHO (1998) (FAO/WHO, 1998). The test meals and a reference food (glucose) were administered to subjects following a randomized, repeated-measures design, with each subject serving as his/her own control. Subjects tested the reference food three times and each test food for one time only. Food testing was carried out on separate occasions with at least a 1-day gap between measurements to minimize any carry-over effects. The reference food provided was 25 g of glucose powder (glucose dextrose monohydrate) dissolved in 200 ml of water. Test foods were tested in equivalent available carbohydrate amounts of 25 g and was also served with 200 ml water. Subjects were encouraged to consume the reference or test foods within 15 minutes and to minimize physical activity during the testing time. Available carbohydrate content was used to determine the experimental portion (g) that would provide 25 g of available carbohydrates from each test food.

Blood glucose measurements

Blood samples were obtained using the OneTouch® UltraSoft™ Adjustable Blood Sampler (Johnson and Johnson, Middle East, Inc.) which uses the OneTouch® UltraSoft™ pen and OneTouch® FinePoint™ lancets. Capillary blood was collected from the third finger on the left hand. Several reports suggested the use of capillary blood rather than venous blood sampling for reliable GI testing (Brouns et al., 2005: FAO/WHO, 1998). A 5 µL blood sample was collected in the microcuvette by capillary action. Blood glucose was measured using the HemoCue Glucose 201$^+$ portable system (HemoCue® Ltd, UK). Calibration of the blood glucose meters was done daily according to the manufacturers' instructions.

A fasting blood sample (0 minutes) was obtained before subjects had consumed any food and further blood samples were obtained at 15, 30, 45, 60, 90 and 120 minutes after the consumption of each food.

Calculation of glycemic response measurements

The incremental area under the blood glucose response curve (IAUC), ignoring the area beneath the baseline, was calculated geometrically (FAO/WHO, 1998). The IAUC for dried *Bisr* and *Tamr* dates eaten by each subject was expressed as a percentage of the mean IAUC for the reference food consumed by the same subject as follows:

GI = (IAUC for the test food containing 25 g of available CHO/IAUC of a reference food with an equal available CHO portion) ×100 (FAO/WHO, 1998: Kris et al., 2010: Dashti et al., 2001)

The GL of a serving of each test food was calculated according to the following formula:

GL = (GI of test food × amount of available CHO in a serving of test food (g))/100 (FAO/WHO, 1998: Kris et al., 2010).

STATISTICAL ANALYSES

Analyses were performed to ensure no violations of the assumptions of normality, linearity, collinearity, and homoscedasticity. Sphericity was tested with Mauchly's test. When the assumption of sphericity was violated, the degrees of freedom were corrected using Greenhouse-Geisser. Data were analyzed using IBM SPSS statistics 23 (IBM SPSS, Chicago, USA). All data were presented as means ± standard deviation. Effects of treatment, time and trial order on study variables were analyzed using repeated measure ANOVA, followed by Bonferroni post hoc adjustment for multiple pairwise comparisons when needed. Effect size was reported as partial eta squared (η_p^2). Level of significance was set at $P < 0.05$.

G*Power 3.1.9.2 software was used for sample size calculation for ANOVA with repeated measures. The calculation revealed the need for a sample size of 15 participants to detect a medium effect size (0.4) with significance level set at 0.05 and power as 0.90. Consequently, a total of fifteen participants were used for GI testing of a single food which is more than the minimum requirement recommended by the International Standards Organisation (ISO 26642:2010 standard) for GI testing (ISO, 2010).

RESULTS

Characteristics of the study population

Participants' baseline characteristics are presented in Table 1. There were no withdrawals or adherence-based withdrawals from the study, and all participants met the adherence requirements during data collection period.

Chemical composition of test foods

The proximate analyses data per 100 g of fresh weight for the test foods are shown in Table 2. Extensive variation is evident between dried *Bisr* and dried *Tamr* dates for

Table 1: Participants' baseline characteristics (*n*=15)

Characteristics	Mean±SD
Age (years)	21.4±1.8
Height (m)	1.61±0.05
Weight (kg)	56.3±4.5
BMI (kg/m²)	21.6±1.7
Fat mass (%)	28.4±4.1
Fat mass (kg)	16.2±3.3
Free fat mass (%)	71.7±3.9
Free fat mass (kg)	40.3±2.8

Table 2: Proximate analysis of dried *Bisr* and dried *Tamr* dates (g/100 g fresh weight basis)

Variables	Dried *Bisr* dates	Dried *Tamr* dates	*P* value
Moisture (g)	6.1±0.21[+]	15.2±1.41	0.012
Ash (g)	3.1±0.14	2.2±0.14	0.03
Fat (g)	0.2±0.03	0.1±0.01	0.019
Protein (g)	2.9±0.24	2.1±0.22	0.03
Crude Fiber (g)	21.3±2.0	9.6±1.4	0.015
Carbohydrate (g)	66.6±1.4	70.8±2.2	0.097
Energy (Kcal)	279.8±6.83	292.5±9.77	0.453

[+]Mean±SD

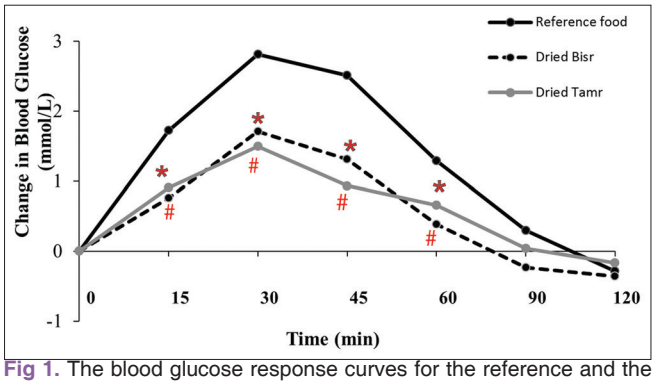

Fig 1. The blood glucose response curves for the reference and the test foods. *Reference food differs significantly from dried *Bisr* (*P*<0.05). #Reference food differed significantly from dried *Tamr* date (*P*<0.05).

moisture (6.1 ± 0.71 vs. 15.2 ± 0.85; *P* = 0.012), and total crude fiber content (21.3 ± 2.0 vs. 9.6 ± 1.4; *P* = 0.015) respectively. Whereas, the carbohydrate and the total energy contents for the tested foods were comparable (*P*>0.05).

Glycemic response and IAUC values

Figure 1 describes the glycemic response curves for the reference and tested food items. The repeated measures analysis of variance revealed an expected significant main effect for treatment on blood glucose values ($F(2, 28) = 21.153$, $P<0.0001$, $\eta_p^2 = 0.602$), with significantly higher response following reference food compared with dried *Tamr* dates (mean difference: 0.606 mmol/L; 95% CI: 0.257, 0.956; *P* = 0.001), and dried *Bisr* dates (mean difference: 0.648 mmol/L; 95% CI: 0.371, 0.926; *P*<0.0001), and no differences between dried *Tamr* and dried *Bisr* dates (*P*>0.05). Additionally, a significant main effect due to time was observed ($F(2.124, 29.734) = 62.488$, $P<0.0001$, $\eta_p^2 = 0.817$). Furthermore, the analysis detected a significant interaction between treatment and time ($F(4.824, 67.535) = 4.750$, $P<0.0001$, $\eta_p^2 = 0.253$). Blood glucose response values were not significantly affected by trial order (*P*>0.05).

The calculated IAUC's values for the reference food and the two test foods are shown in Figure 2. The repeated measures ANOVA demonstrated a significant main effect for treatment (type of food) on IAUC ($F(2, 28) = 46.375$, $P<0.0001$, $\eta_p^2 = 0.768$), with reference food IAUC being higher (164.5 ± 47.8) in comparison with dried *Bisr* (88.5 ± 24.1, *P* < 0.0001) or dried *Tamr* dates (88.2 ± 27.9, *P* < 0.0001), while no significant differences were detected between the test foods (*P* > 0.05).

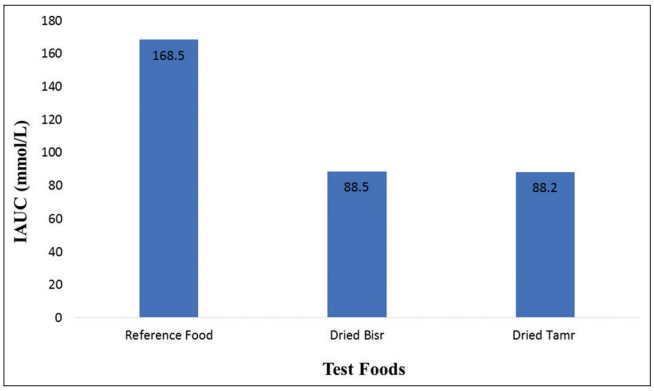

Fig 2. The IAUC values for the reference and the test foods. *Test food differed significantly from reference food (P<0.05).

GI and GL classification of test foods

The GI test is based on 25 g of available carbohydrate in each test food, defined as the total carbohydrate minus the dietary fiber. Table 3 shows the portion size of each test food, GI and GL values and the classification of the test foods. The GI values for test foods were 54.6 and 54.3 for dried *Bisr* and dried *Tamr* dates, respectively, classifying them as low GI foods. However, the GL values for the two tested foods were comparable and fall into the medium-GL category. (Gilbertson et al., 2001: Alkaabi et al., 2011).

DISCUSSION

Dates are the main fruit in Arabian Gulf Countries including the UAE; they are widely consumed there and in most other Middle Eastern and Islamic countries. They are one of the most significant commercial crops and have also been documented in the Holy Quran. However, there is little information available about GI and GL of different date varieties. For practical applications, GIs are often grouped into low (<55), medium (56–69), or high (≥70) glycemic response categories (Miller et al., 2003).

A similar GL classification system is used, in which foods are categorized as having low (≤10), medium (10–20) or high GL (≥20) (Miller et al., 2003).

Date fruits can be consumed during three stages of maturity namely: *Bisr* (or *Khalal*), *Rutab* and *Tamr*. People in the Arabian Gulf region consume *Rutab* (ripe dates) in summer and *Tamr* (dried dates) in all seasons. *Khalal* (*Bisr*) and dried dates are considered good sources of

Table 3: Glycemic index (GI) and glycemic load (GL) values and classification of dried *Bisr* and dried *Tamr* dates

Test food	Available CHO (g)	Experimental portion (g)	GI		GI classification	GL	GL classification
			Mean	SD			
Dried *Bisr*	25	37.5	54.6	15.2	Low	13.65	Medium
Dried *Tamr*	25	35.3	54.3	14.3	Low	13.58	Medium
P value			0.913			0.889	

some nutrients, such as ascorbic acid, carotene and many phytochemicals (Sidhu, 2007).

To the best of our knowledge, the current study is the first to analyze the composition and GI of date fruits at the *Bisr* stage. The findings on *Tamr* obtained in this study are similar to those reported in other international studies (Alkaabi et al., 2011: Miller et al., 2003: Gilbertson et al., 2001). The low GI values observed for dried dates and dried *Bisr* were similar to those reported in *Sabaka*, *Nabtat-seyf*, *Ruthana*, *Rashodia*, *Wannanah*, *Shishi*, *Sag'ai*, *Sukkary* and *Shaqra* dates (AlGeffari et al., 2016). The similarity was also seen with GIs of the five types of dates popular in the UAE; *Fara'd*, *Lulu*, *Bo ma'an*, *Dabbas* and *Khalas* (Alkaabi et al., 2011).

The fiber content varies depending on the type and degree of ripeness (Baliga et al., 2011). The percentage of fiber decreases throughout the stages of maturation with the lowest percentage at the *Tamr* stage (Baliga et al., 2011: Bouaziz et al., 2013). This explains the significant differences between *Bisr* and dried *Tamr* date in fiber content (21.3 ± 2.0 vs. 9.6 ± 1.4; $P = 0.015$) respectively. International tables suggest that the mean GI±SEM for dates is 42, which is low GI.

The low GI value for dried dates (*Tamr*) and dried *Bisr* dates may be attributed to high fructose contents as reported by (Alkaabi et al., 2011) as in *Fara'd*, *Lulu*, *Bo ma'an*, *Dabbas* and *Khalas dates*. In 2008, Elleuch (Elleuch et al., 2008) observed that *Bisr* dates contain more of the health-promoting dietary fiber and less sugar than *Rutab* and *Tamr* dates. It has been suggested that dietary fiber may reduce the postprandial blood glucose responses, simply by reducing the speed of absorption of carbohydrates as a result of the formation of a viscous gel-like structure in the gastrointestinal tract (Ali et al., 2009).

GL is a useful measure of the true glycemic response because it considers portion size. Although a higher GI and GL both suggest that a food could cause a significant increase in blood glucose levels, GL considers realistic portion sizes and so could be more accurate (Griffith et al., 2008).

GL values for both test food items were intermediate, which is similar to *Sabaka*, *Nabtat-seyf*, *Ruthana*, *Rashodia*, *Wannanah*, *Shishi*, *Sag'ai*, *and Sukkary* dates (AlGeffari et al., 2016). The GL for dried dates and dried *Bisr* can be reduced if the portion size of consumed dates is adjusted to 27 g for both types, which is equivalent to 3 to 4 dried dates. In addition, consuming dates with yogurt and cheese can further reduce GI and GL (Flint et al., 2004: Henry et al., 2006). The implication of these results is that consumption of dates in similar quantities as were used in this study will not result in rapid or large fluctuations in blood sugar even when eaten alone. Furthermore, a low GI diet demonstrably improves HbA1c levels, body weight and the lipid profile, as was seen in other studies (Ford and Liu, 2001: Buyken et al., 2001). Although dates have long been referred to as 'the candy that grows on trees', it would seem they are not like candy in terms of the glycemic response to their ingestion, which is consider as good news for diabetic individuals. Low GI has also been reported for other fruit such as berries and it was suggested that the fiber and/or polyphenols present in lingonberries null the glycemic effect of the sugars present in the berries (Linderborg et al., 2012).

CONCLUSION

This study shows that date fruits, at the *Bisr* and *Tamr* stages, have similar effects to those of berries, although the reason for this phenomenon is not known. In addition, GI for dried Bisr and dried Tamr are low with moderate GL, which indicates similar glycemic responses regardless of their maturity stage.

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Author Contribution

Conceptualization: AKE, ASA; methodology: ASA, AKE, and AHJ; supervision of experiment:s: ASA, AKE, and AHJ; data analysis: ASA, AHJ, and MFB; resources: AKE; writing—original draft preparation: AHJ, ASA and MFB; writing—review and editing: ASA, AHJ, MFB, and AKE; funding acquisition: AKE. All authors read and approved the final manuscript.

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Competing interests

The authors declare that they have no competing interests.

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