Research Paper

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Effect of Adding the Spirulina (Arthrospira platensis), to Date Syrup on Glycemic Response and its Effectiveness to Reduce Post Prandial Blood Glucose

Natural Science

KEYWORDS : Algeria; Date, Syrup, Glycemic Index, Spirulina, Protein, Diabetes

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ABSTRACT

The date palm care, Algeria an important place in agriculture. The date is known for its richness in various nutrients such as sugars, minerals, and fiber. The aim of this research is to develop a syrup from the dates and spirulina with a low glycaemic index for use by the obese and diabetics. Spirulina, described as "the richest food in the world", is a true protein concentrate (70%). Syrup was manufactured from the Ghars cultivar by diffusion method at 80 °C for 24 hours followed by concentration at 60°C. To this syrup 1 to 2% of spirulina was added. The study subjects were seventeen healthy volunteers. Each subject was tested on separate days with 50 g of glucose, 50 g equivalent of available carbohydrates from the Ghars cultivar, pure date syrup, and the syrup supplemented with spirulina (1% and 2%). The mean glycemic indexes were between 43.40±9.74, 61.51±10.98. There is statistically significant difference in the GI between Ghars cultivars and the dates syrups, ANOVA; (Fcalculated = 15,07 , Ftheoretical = 4.96) and there is no statistically significant difference between pure syrup and spirulina supplemented syrups (Fcalculated = 0,11, Ftheoretical = 4,96). The determined glycemic load for the spirulina supplemented syrup was 20.01±4.65 and 19.7±4.48, for 1% and 2% respectively, thereby classifying them as average glycemic load foods. The results show low GI for spirulina supplemented syrup. These findings point to the potential benefits of these products for diabetic subjects when used in a healthy balanced diet.

INTRODUCTION

The date palm (*Phoenix dactylifera L.*) is one of mankind's oldest cultivated plants. It has always played an important part in the economic and social life of the people of arid and semiarid regions [1], [2] and [3]. The importance of the date palm tree was appreciated by many nations over the centuries. This is in part due to its nutritional value. Dates are rich in carbohydrates (70 – 80 %) comprising of sugars and dietary fibers, making it one of the most nourishing natural foods available to the man. Dates are also a good source of some vitamins (A, B1, B3, C) and micro-elements like phosphorus, iron, potassium and calcium [4], [5], [6], [7], [8] and [9]. They are also being exceptionally rich in potassium and extremely low in sodium; is a desirable food for hypertensive persons who are advised to consume low sodium diets. The increase in dates' production will, therefore, play an extremely significant role in worldwide improvement of the nutritional status of people, with special reference to calories and important minerals [10] and [11]. Besides the nutritional value, dates also contain various phenolics and flavonoid compounds [7], [12], [13], [14], [15] and [16].

One of the features of the Algerian phoenicicole orchard is its genetic diversity. In fact, there are nearly 1000 varieties of date palms in Algeria [17]. To preserve this heritage phoenicicole, it is necessary to install technological and industrial processes for the development of products from the date to enhance its consumption worldwide such as, syrups [9] vinegar, jam, marmalades, biscuits, etc [4].

Date syrup; is probably the most common derived date product. In food technology, date syrups are used for foodstuffs such as marmalades, concentrated beverages, chocolates, ice cream, confectioneries, bakery products and etc [11], [18] and [19].

The date syrup are characterized by their high sugar content (≥ 80%) [11], [20] and [21], so there is a problem with their consumption by certain categories, especially diabetics and those on diet. Meanwhile, the date syrup is known by their poverty in protein (0 -2%) [11], [20], [21] and [22]. To increasing their dietary value, it is necessary to combine with a food rich in protein such as microalgae consumables (Spirulina).

Spirulina (*Arthospira platensis*) is a food cyanobacteria (blue-green) of 0.2 to 0.3 mm length. It is described as the "the richest food of the world", is a veritable protein concentrate (70%) [23] and [24]. In addition to its exceptional nutritional quality, the ease of culture, high productivity and low cost of production compared to other aquaculture products. It was proposed in the human diet as a dietary supplement by many scientists and nutritionists [25].

The glycemic index (GI), first proposed in 1981[26], is a system of classifying food items by glycemic response. The GI of a food depends upon the rapidity of digestion and absorption of its carbohydrates, which is determined largely by its physical and chemical properties. A particular food's GI is determined by measuring the rise in blood glucose after ingestion of a quantity of that food containing 50 g carbohydrate equivalent compared with the same amount of carbohydrate from a reference (such as glucose or white bread) taken by the same subject [27] and [28]. Using glucose as the reference (100), a GI of ≤ 55(i.e. ≤ 55% of the reference) is considered low, of 56-69 is considered medium, and of ≥ 70 is considered high [26].

The glycemic load (GL) glycemic index, because it takes full effect "anti-glycemic" of fiber present in the food, and the amount of carbohydrate and fiber in a serving. The load thus gives the amount of "available" carbohydrate in a serving [29]. The main objective of this study is to assess glycemic response (Glycemic Index) and to know effectiveness of spirulina supplemented date syrup in the reduce post prandial blood glucose, in an attempt to contribute to improving the management of eating habits Saharan populations, including those with diabetes.

MATERIALS AND METHODS

PLANT MATERIAL

Ghars date palm cultivar was selected for this study on the basis of its soft consistency, facilitating the extraction of diffusion

syrup. Dates were harvested at the Tamar (mature) stage from groves located in the region of Ouargla (Fig. 1).

Spirulina used was in the form of dried powder, cultivated in the Ouargla region, southern Algeria (fig.1). It has a dark green color with an acceptable taste and odor. This powder is kept in a sealed box to protect from moisture.

VOLUNTEERS

The volunteers were recruited for this test received a questionnaire about their current health status. Each subject underwent a complete physical examination including measurements of height, weight, body mass index (BMI). The subjects chosen were non-diabetics. Exclusion criteria for volunteers included morbid obesity (BMI > 40 kg/m2), pre diabetes, any alcohol intake, smoking, taking any medications and the presence of chronic diseases. Seventeen healthy subjects (Ten for dates test and seven for date syrup test) were enrolled for the study (Table 1). These numbers were chosen based on standards published by the FAO for the determination of the GI of food with states six subjects as sufficient [30].

TABLE – 1
CHARACTERISTICS OF THE VOLUNTEERS

Parameter	Healthy (n = 17) Mean ± SD
Age (yrs)	24 ± 1.03
Body weight (Kg)	51.55 ± 9.79
Height (m)	1.60 ± 0.13
Body mass index (Kg/m^2)	23.18 ± 2.90
Fasting blood glucose (g/L)	0.99 ± 0.03

PRODUCTION OF DATE SYRUP

The date syrup was produced throughout two major stages; extraction by diffusion and concentration [31] and [32]. The whole date fruits were extracted three times in an Erlenmeyer flask (1000 ml-capacity) with water using a dates: water ratio of 1:2 (w/w) maintained at 80°C for 24 h. The resulting solution was then filtered through a 1 mm filter to remove any solids. Concentration of the syrup was then achieved by evaporation of water in an oven set at 60°C until the syrup was 72-75° Brix (Fig. 1). The compositions of the dates and date syrup were analyzed using standard methods [33].

FORMULA OF THE TEST FOODS

The amount of date syrup corresponding to 50g of carbohydrates used to prepare food formula (61.93 g of syrup). Three food formulas were prepared for this test: the date syrup without spirulina, date syrup with 1% spirulina and date syrup with 2% spirulina.

MEASUREMENTS OF BLOOD GLUCOSE

Glucose was measured in capillary blood samples using glucometer (Accu-Chek Active), which uses the glucose oxidase method. This apparatus contains corresponding test strips and needles. A small blood drop is sufficient for Accu-Chek active to perform a blood glucose test (1-2µl.). The results are displayed on the screen automatically, and this unit measures the glucose values within a defined range (0.1 to 6 g /l).

DETERMINATION OF GLYCEMIC RESPONSE

Glycemic index (GI) testing was carried out after an overnight fast, the test is performed on successive four days (ten volunteers to test dates in two days and seven volunteers to test the formulas proposed of date syrup in four days). The first day utilized 50 g of glucose dissolved in 250ml ml distilled water followed sequentially (second to fourth days) by 50g carbohydrate equivalents of the dates (weight consumed 69.64g), pure date syrup, date syrup with 1% spirulina and date syrup with 2% spirulina (weight consumed 61. 93 g).

Blood glucose was monitored during 2 hrs at 0, 15, 30, 45, 60, 90 and 120 min [27]. Areas under the curve (AUC) of blood glucose concentrations resulting from glucose given orally in a dose of 50 g with a corresponding oral carbohydrate load of 50 g were compared as previously described by Wolever et al. [34]. The 50 g of glucose was used as the reference food (GI = 100) against which test dates and dates syrups were compared. The areas under the incremental glycemic-response curves for each aliment tested were expressed as a percentage of the mean area under the glucose curves for the same subject. The resulting values for all subjects were averaged to calculate the GI for each aliment tested. The blood glucose levels used to calculate GIs were measured in our research laboratory in the Faculty of Natural Sciences and Life Sciences and Earth and the Universe, Algeria University between March and April 2013.

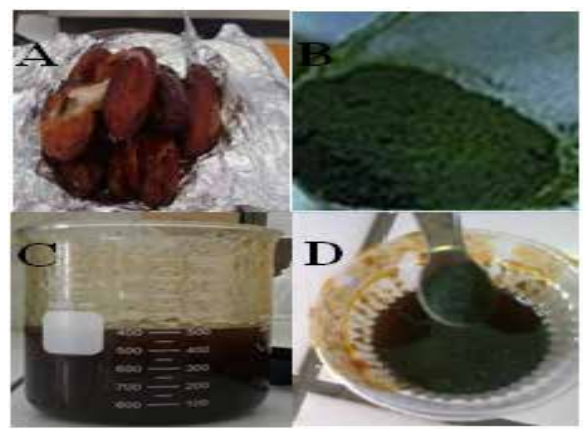

Figure 1: Plant materials. A. shows the Ghars cultivar dates; B. powder of spirulina; while C. highlights the date syrup prepared; D. is a test food prepared.

CALCULATION OF GLYCEMIC LOAD

The glycemic load (GL) is directly related to glycemic index, because it takes full effect "anti-glycemic" of fiber present in the food. It gives the amount of available carbohydrates in food [29]. GL is calculated by the following formula:

$$GL = \frac{GI \times CC}{100}$$

CC: Carbohydrates Content

STATISTICAL ANALYSIS

Data were analyzed using MATLAB program. For each aliment tested the GI was measured by calculating the area under the curve using the following formula:

$$GI = \frac{\text{Areas under the curve (AUC) aliment tested}}{\text{Areas under the curve (AUC)reference food(glucose)}} \times 100$$

Standard descriptive statistics were used and results are presented as means and standard deviations (SD) or standard errors of the mean (SEM). The statistical analysis of data was performed using analysis of variance (ANOVA). Compared elements were considered statistically different when the probability value P ≤0.01.

RESULTS AND DISCUSSION

COMPOSITION OF DATES AND DATE SYRUP

As illustrated in Table 2, the selected date fruits pulp (Ghars) contained 16.42 ± 0,73% moisture and 83.57 ± 0.73% total solids. It also contained 1.10 ± 0.01, 02,10 ± 0.10 and 4.70±0.32% protein, ash and fiber, on dry weight basis, respectively. From the former Table, it could be also observed that total sugars are the major constituent of date pulp (71.79 ± 0.02% of total solids) and

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the reducing sugars represented 70.00 ± 0.01% of the total solids of date flesh. While, the amount of sucrose is negligible 01.70 ± 0.09%. These results are in accordance with those published by Alkaabi et al. [22] and Ganbi [21], with some negligible variation as the result of the differences in date variety tested, stage of maturity, the location of growing, and the climate conditions.

TABLE-2
CHEMICAL COMPOSITIONS OF THE FLESH DATE AND DATE SYRUP

Analysis (%)	Ghars Cultivars	Date Syrup
Total solids	83.57 ± 0.73	79.56±1.30
Moisture	16.42 ± 0.73	20.44±0.30
Fiber	4.70± 0.32	2.86 ±0.12
Protein	1.20 ± 0.01	1.10 ±0.04
Total sugars	71.79 ± 0.02	70.63±0.10
Reducing sugars	70.00 ± 0.01	70.05±0.01
Sucrose	01.70 ± 0.09	0.55 ±0.02
Ash	02,10 ± 0,10	0.96±0.046

Date is rich in certain nutrients and is widely consumed in many countries, particularly those within the Middle East and North Africa. Our studied type of date is rich in carbohydrates with two monosaccharides, glucose and fructose, as the main reducing sugars. As fructose is twice as sweet as glucose, it plays an important role in the flavor and it is a good nutritional and dietary source from dates.

The measurement of the percentage of dietary fibers (4.70 ±0.32%) was higher to that previously reported by Alkaabi et al. [22] (2 – 3%). This variability in the reported dietary fiber content might be explained primarily by the different date cultivar. The tested date contain a similar percentage of protein those recorded by Alkaabi et al. [22] (1.16 – 1.62 %). These values are lower for a food product. Our date was also rich in minerals because the value of ash is equal 02.10 ± 0.10%. This result is in accordance with those cited of Elleuch et al. [5] for Tunisian cv Deglet Noor (2.5%).

The extraction procedure (triple diffusion) of date syrup improves the yield of solutes to 47.5% after concentration at 60°C for cultivars Ghars compared to previously published protocol [9]. This value is higher compared to that recorded for same cultivar (Ghar 25%) [5] and [21], which were between 38.94 and 41.37%. Thereby, with tested novel extraction procedures; pectinase / cellulase enzymatic technique, microwaving and ultrasonic procedure the yield was found to be 83.10 %, 77.52 % and 83.96 %, respectively [21]. The applied novel extraction procedures; especially ultrasonic procedure, exhibited a significant much higher efficient in extracting the soluble solids from date fruits.

The analysis of samples of the studied date syrup gave the following composition: 79.56±1.30, 20.44±0.30, 2.86 ±0.12, 1.10 ±0.04, 70.63±0.10, 70.05±0.01, 0.55 ±0.02 and 0.96±0.046% for total solids, moisture, fiber, protein, total sugars, reducing sugars, sucrose and ash, respectively (Table 2). The protein deficiency compared to total sugars is remarkable in this product. These results are awaited as a result of the passage of a significant amount of nutrients from dates towards the syrup [9]. The obtained results also showed that this date syrup can be used as a base for the development of other dietary products.

There were 17 healthy subjects with a mean (± SD) fasting blood glucose 0.99 ± 0.03 (g/L), age of 24 ± 1.03 years and BMI (± SD) of 23.18 ± 2.90 kg/m2 (Table 1). These data allowed us to recruit 17 volunteers.

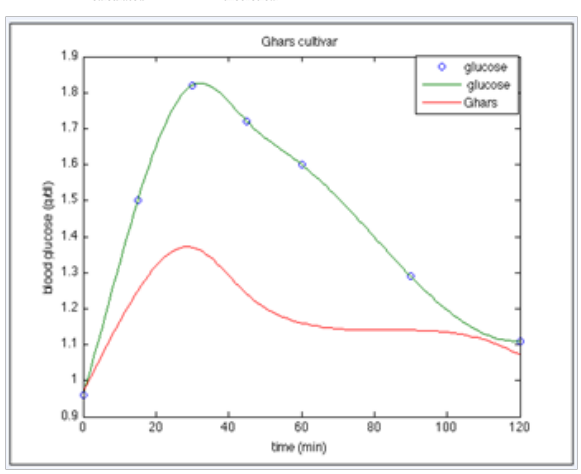
GLYCEMIC RESPONSE
Figure 2 is graphic presentation of the peaks postprandial hyperglycemia for cultivars Ghars and three food formulas respectively.

The peak of hyperglycemia obtained with pure glucose (50g) for date and food formulas tested at 15 and 30 min achieved 1.8 and 2.06 g/l respectively, because pure glucose is a simple sugar easily absorbed. This absorption is followed by an immediate and a high peak of hyperglycemia which lasts a short duration. The consumption of four test food did not result in significant postprandial glucose excursions. This variation between tests foods can be explained by their composition and metabolic heterogeneity of volunteers. The peaks of hyperglycemia obtained for date, pure date syrup, date syrup with 1% spirulina and date syrup with 2% spirulina achieved : 1.37, 1.55, 1 et 0.99 g/l at 15 min respectively. These results can be explained by the important content of fiber in dates and proteins in spirulina modified syrups (spirulina source) which slow gastric emptying [35] and [36].

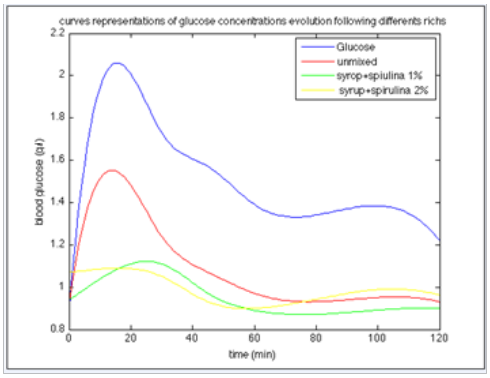
Note that according Hlebowicz et al. [37], the consumption of dietary fiber has been shown a significant reduction in risk of developing diabetes. According to their study, they did not show any increase in the level of glucose in the blood after eating a meal of whole rye grains (bread) compared to reference food. The authors found hyperglycemia peaks at time 40 min reaching 0.48g/l. For comparison, Jenkins et al. [35] confirm the results found by previous authors. They showed that the reduction in post-prandial glucose was remarkable after incorporation of viscous polysaccharides (NVP) or commercial fibers in food. The authors report that the addition of 5 g of NVP in breakfast, starch, rice, roast turkey and yogurt allowed having hyperglycemia peaks the order of 0.53, 0.38, 0.51 and 0.61 g /l respectively against 0.84, 0.76, 0.82. and 0.74 g / l respectively for the same food without NVP. The composition of a food affects blood glucose response through the concept of glycemic load, more food is rich in macronutrients other than carbohydrates, glycemic response will be the less and will influence on blood glucose [35].

GLYCEMIC INDEX
Table 3 shows the GI results for Ghars cultivars and three food formulas. The measured mean ± SEM GIs were 43.40±9.74, 61.51±10.98, 56.03±4.58 and 55.22±4.45 for Ghars, pure date syrup, date syrup with 1% spirulina and with 2% spirulina, respectively.

There is statistically significant difference in the GI between Ghars cultivars and the dates syrups, ANOVA; ($F_{calculated}$ = 15,07 , $F_{theoretical}$ = 4.96) and there is no statistically significant difference between pure sysup and spirulina supplemented syrups for 1% and 2% ($F_{calculated}$ = 0,11, $F_{theoretical}$ = 4,96).



A



B

Figure-2. Mean Capillary Glucose Concentrations Following A: Ingestion of Date (Ghars) in Ten Subjects; B Three food Formulas in Seven subjects. Data are Expressed as the Changes in Capillary Glucose Concentration From the Fasting Baseline Concentration. Each Data Point Represents the Mean Value for all the Subjects and the Standard Error of the Mean.

The Ghars cultivars, therefore, is low GI food items. In our study, the mean GI is comparable to the range GIs of the five types of dates reported by Alkaabi et al. [22], with was 46 to 55 for healthy subjects and 43 to 53 for the type 2 diabetic patients. Thereby, Miller et al. [38] were found IG for Khalas and Bo maʾan 35.5 and 30.5 respectively, and the mean GI for Khalas with yoghurt mixed meal was 35.5 [39]. The GIs of three cultivars of dates collected from various regions of Oman ranged between 47.6 and 57.7 [40]. From international tables, the mean GI ± SEM for dates is 42 ± 4 [41].

According to these results, we can classify GI for dates as low to medium food items (mostly low GI food items). The low GI of dates can be attributed to their high fructose and dietary fiber content (Table 2). In our study, the Ghars is soft cultivars, so glucose and fructose ratio is approximately 1:1 [9]. This can be justified by the low GI fructose (23). Concerning, GI of pure date syrup seems high compared to that of date, this can be justified by the method of extraction by diffusion, which allows passage of a portion of the date components (fiber) (Table 2). The GI of pure date syrup goes from 61.51 to 56.03 with 1% spirulina and 55.22 with 2% spirulina. This explained by the presence of fiber and protein which reduce the rate of digestion, makes carbohydrates less readily available and therefore lowers the GI and limit the peak postprandial hyperglycemia [35] and [36]. We also found that the percentage of spirulina in the syrup could modify the glycemic index.

In this study, the glycemic load (GL) date syrup with spirulina was between 19,72 - 20,01, this allow us to classify our products from foods average GL. However, the GL of Ghars and date syrup without spirulina is 21.96 and 30.96 respectively, these values seem high compared to recommend in the literature (less than 20).

Whereas our estimates of the GIs are similar to previously reported values [22], [38], [39] and [40]. Our results show that the consumption of syrups rich in spirulina did not result in significant postprandial glucose excursions, suggesting that patients especially diabetics, can consume date and spirulina supplemented syrups in similar quantities to those used in this study without the risk of inducing undesirable postprandial excursions in blood glucose.

TABLE 3
MEAN GLYCEMIC INDICES AND GLYCEMIC LOAD OF DATE AND FOOD FORMULAS

Test food Glucose (reference)	Mean GI ± SEM 100	Mean GL ± SEM
Ghars cv	43.26±14.06	30.96±1.11
Pure date syrup	61.51±13.3	21.96±4.71
Date syrup + 1%	56.03±13.05	20.01±4.65
Date syrup + 2%	55.22±12.56	19.72±4.48

CONCLUSION

According to this study, we have determined the composition of Ghars cultivars and evaluate the post prandial response of the food formulas and calculated their glycemic index. Our results show that the consumption of spirulina supplemented syrups did not result in significant postprandial glucose excursions, suggesting that healthy and diabetic subjects can consume these products in similar quantities to those used in this study without the risk of inducing undesirable postprandial excursions in blood glucose. Thereby, the results may help diabetic subjects and their health care providers in developing a diet that is both medically and culturally appropriate.

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