Glycemic Index in the Development of Functional Beverage

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Abstract

Background: Due to the prevalence of diabetes in Jamaica, an understanding of the glycemic index (GI) and glycemic load (GL) values of beverages and food can aid dieticians in guiding consumers to choose sensibly. It is reported that consumption of low GI and GL foods may reduce the risk of type 2 diabetes, coronary heart disease and obesity. However, low GI snacks/food available to diabetic patients in Jamaica are very limited. This study was conducted to develop a low GI and GL vegetable drink that could be commercialized.

Methods: Ten (10) healthy Jamaican subjects (5 males and 5 females) with mean age 30 ± 2 years and mean BMI 25 ± 1 kg/m^2 were recruited to the study. Using a non-blind, crossover design trial, the subjects consumed equi-carbohydrate amounts (25 g of total available carbohydrate) of the vegetable (beetroot – *Beta vulgaris*, cucumber – *Cucumis sativus* and carrot – *Daucus carota*) drink and twice glucose as reference food (25 g of total carbohydrate). Blood glucose was determined after overnight fasting (0 hours) and at 15, 30, 45, 60, 90 and 120 minutes after the consumption of each test food. The glycemic index (GI) value was calculated geometrically by expressing the incremental area under the blood glucose curve (IAUC) as a percentage of each subject's average IAUC for the standard food.

Results: The GI and GL values of the vegetable drink were found to be 34 ± 10 and 4.4, respectively. As per the Food and Agriculture Organization, GI cut-off values are as follows: low <55; medium 56-69 inclusive, high >70 and for GL, low ≤ 10, medium 10 to 20 or high ≥ 20. Hence the vegetable drink could be classified under low glycemic food/nutrient.

Conclusion: Identification of beverages and other foods with low glycemic responses may have practical applications in controlling blood glucose levels. This study provides scientific evidence of the blood glucose response of the formulated vegetable drink. The complex carbohydrates in beetroot, carrot and cucumber may be responsible for the low postprandial glycemic response. This will lead to a low demand for insulin secretion from the pancreatic β cells, which are often impaired in type 2 diabetic individuals.

Keywords: Glycemic index; Diabetes; Hyperglycemia

Introduction

Diabetes mellitus (DM) is one of the leading causes of death in many countries; therefore an effective method of management is of absolute importance. This metabolic disorder is characterized by high blood glucose level and abnormalities in carbohydrate, protein and fat metabolism [1]. The rising prevalence of diabetes and its complications in recent times has push scientists to develop means of mitigating further increase. Type 2 diabetes mellitus can be managed by lifestyle changes (diet and exercise) as well as the administration of drugs such as metformin, which aids in the control of the blood glucose. Jenkins and others first postulated the theory of glycemic index at the University of Toronto in 1981 as a means to manage type 2 diabetes [2].

The glycemic index is theoretically defined as the post-prandial blood glucose response elicited by a given amount of food that contains 50 g (or in some cases 25 g) of available carbohydrate (CHO), expressed as a percentage of that elicited by 50 g (or 25 g) of the reference carbohydrate (glucose solution or white bread) in the same subject [3]. This index or percentage represents a property of the food, which indicates the quality of the existing carbohydrate. Foods with carbohydrates that are digested, absorbed and utilized quickly are referred to as high glycemic indexed foods (GI ≥ 70). Those absorbed moderately (56-69) are referred to as medium GI foods, while those that are digested, absorbed and utilized slowly are referred to as low GI (GI ≤ 55) foods [4].

Glycemic load represents the product of the GI and the total available carbohydrate content in a specified portion of food divided by 100. GL values are also categorized as low (≤ 10), medium (>10 to <20) or high (≥ 20). Pharmacological interventions aimed at improving glycemic control in type 2 diabetes have shown positive results. However, additional improvements in diabetes management have been reported

when diets of low GI foods are consumed in comparison to those with high GI foods. To date, it is documented that stringent pharmacologic glycemic controls have not demonstrated the expected distinct benefits for coronary heart disease among type 2 diabetic individuals [5,6]. Therefore, pharmacotherapy may prove to be only part of the solution. These research findings indicate that dietary approaches that both impact on blood glucose control and reduce coronary heart disease risk and associated risk factors should be highlighted. Due to the limitations of current therapies for DM, there remains interest in alternative and/or complementary treatments. This study was conducted to develop a low GI and GL vegetable drink and make it commercially available [7,8].

Materials and Methods

Study population

Ten (10) healthy Jamaican subjects (5 males and 5 females) were recruited for the study. Subjects were non-smoking, non-alcoholics, moderately active with mean age 30 ± 2 years and mean BMI 25 ± 1 kg/m^2.

Study design

Non-blind, repeat measure, crossover design trial.

Design of experiment

Proximate analysis for carbohydrate, fat, crude protein, moisture, dietary fiber content and ash were determined using the AOAC standard. Total carbohydrate was done by difference according to FAO/WHO Expert Consultation protocol.

Ten (10) healthy Jamaican subjects, comprising five (5) males and five (5) females with mean age 30 ± 2 years and BMI 25 ± 1 kg/m^2 were recruited to the study. Proportion of vegetable drink

equivalent to 25 g of available carbohydrate was fed to subjects after a 10 hour overnight fast and their serum glucose levels were determined at 0, 15, 30, 45, 60, 90 and 120 minutes [9]. The incremental areas under the curve (IAUC) were calculated according to the method of Brouns et al. A cup of glucose, 25 g in 250 ml was used as the standard, which was assigned a GI of 100. Glucose was tested on three separate occasions, and the test foods once. The GI rating (%) for each food, was calculated for each subject by expressing the IAUC of the test food as a percentage of the average IAUC of the glucose standard consumed by that volunteer [10,11]. The protocol was approved by the Ethics Committee of the University Hospital of the West Indies and the Faculty of Medical Sciences at the University of the West Indies Mona Campus, Kingston, Jamaica.

Test food

Vegetable drink consisted of beetroot (*Beta vulgaris*) 2%, cucumber – (*Cucumis sativus*) 6%, and carrot (*Daucus carota*) 25% as main ingredients.

Statistical analysis

Statistical analysis was performed using SPSS. Data obtained from the experiments are expressed as mean ± SE. Values of P ≤ 0.05 were considered significant using Students t test [12].

Results

Table 1 shows the proximate composition of the vegetable drink. The crude protein (0.17 g), ash (0.09 g), moisture (97.0%), total sugar (2.40 g), iron (<0.10 mg/ml), vitamin C (3.70 mg/ml) and carbohydrate (5.30 g) was determined in 100 ml of vegetable drink. **Figure 1** and **Table 2** shows the mean blood glucose values after consumption of vegetable drink and glucose standard [13-15].

Table 1. Proximate composition of vegetable drink (100 ml).

Sample	% Crude Protein	% Ash	% Moisture	% Total Sugar	Iron mg/ml	Vitamin C mg/ml	% Carbohydrate
Vegetable Drink	0.17	0.09	97	2.4	<0.10	3.7	5.3

Table 2. IAUC upon consumption of glucose and vegetable drink.

	Blood glucose concentration (mmol/l)									GI	GL
	n	0	15	30	45	60	90	120	Mean IAUC		
Glucose	10	4.9 ± 0.17	6.2 ± 0.2	7.0 ± 0.12	6.5 ± 0.2	6.1 ± 0.3	4.7 ± 0.2	4.6 ± 0.2	104.0 ± 14	34.6 ± 9	4.4
Vegetable Drink	10	4.8 ± 0.1	5.7 ± 0.3	6.2 ± 0.3	5.2 ± 0.3*	4.5 ± 0.2*	4.5 ± 0.2	4.3 ± 0.2	32.6 ± 8*		

Values are mean ± SE for n=10 subjects
IAUC- Incremental area under the curve
GI- Glycemic index
Paired "t" was done to assess the difference in blood glucose levels at different time intervals upon consumption of test food and standard.
*Significantly different (P<0.05)

There was a significant increase in the postprandial blood glucose levels after consumption of glucose standard (P ≤ 0.05)

when compared to the vegetable drink. In addition, the vegetable drink showed a significantly lower overall blood

glucose response during the first two hours after consumption than the glucose standard [16,17]. Hence the mean IAUC of the vegetable drink was observed to be significantly lower (32.6 ± 8) than that of the glucose standard. The GI value of the vegetable drink was found to be low (34.6 ± 9). GI values can be categorized as low <55, medium 56-69 inclusive and high >70. Similarly, the GL (high ≥ 20, medium 11-19 and low ≤ 10) of the vegetable drink was determined to be low (4.4) [18].
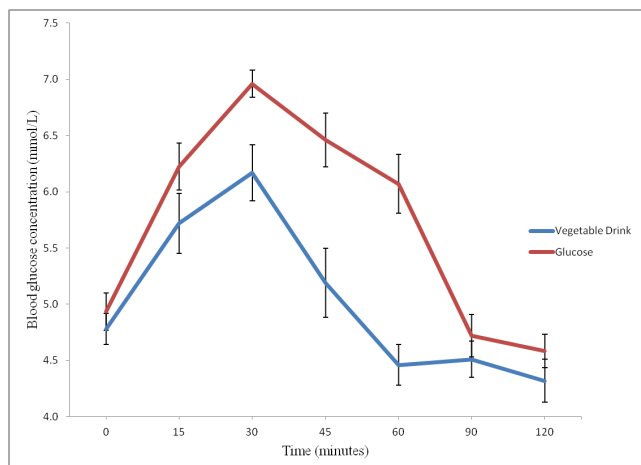
Figure 1. Mean blood glucose concentration in healthy subjects after consumption of glucose or vegetable drink.
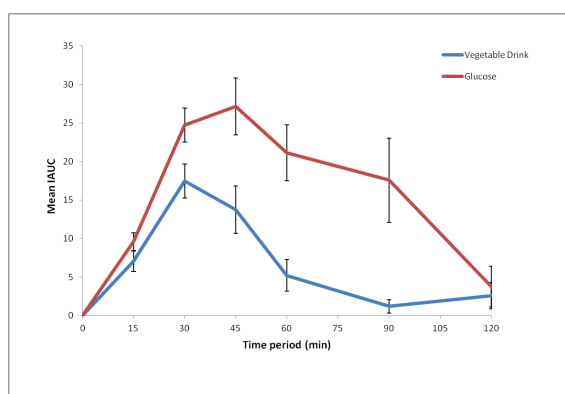
Figure 2. Incremental AUC for blood glucose concentration in healthy subjects after consumption of glucose or vegetable drink.

Discussion

The vegetable drink showed significantly lower glycemic response compared to the glucose standard (P ≤ 0.05) [19]. The vegetable drink had a low GI of 34.6 ± 9 and a low GL of 4.4. This low GI and GL could be due to the fiber content of the main ingredients (beetroot, cucumber and carrot) of the drink. The dietary fiber could alter the digestion and adsorption of the carbohydrate present and thereby influence blood glucose response [20,21]. The presence of acidity may also alter blood glucose response indirectly by slowing down gastric emptying,

resulting in slower rate of digestion with subsequent reduction in glucose absorption.

The GL of the vegetable drink assesses the glycemic effect of the serving sizes of different foods. The GL of the vegetables drink was determined to be low based on the recommended serving size of 240 ml for beverages. Similar results of low GI (30 ± 3) and low GL (7) was observed by researchers in Australia when investigating glycemic response of a banana smoothie drink [22,23]. They also reported the GI of a popular carbonated drink to be medium (68 ± 6) and GL high (23). Other researchers in the United States of America also investigated the GI and GL of a popular carbonated beverage and a fruit punch, however, both beverages were reported to have high GI and GL. Researchers in Sub-Saharan Africa investigated the GI and GL of four local drinks and reported that the four drinks had low GI, however the GL of the drinks were medium. Studies conducted by Salmeron et al. and Schulze et al. demonstrated that foods with high GL elevate glycemia and insulinemia in human subjects [24,25]. In addition, the risk of diabetes and cardiovascular diseases also increases with consumption of foods with high GI and GL. However, consuming foods with low GI and GL will have health and disease prevention benefits according to researchers Egan, Read, Riley, & Atiomo, Salehi and Yousefinejad & Pishdad [26-28]. Therefore, the vegetable drink formulated in this study with a low GI and GL may have beneficial health effects if made available to patients with diabetes and its associated complications, as well as to individuals that are interested in consuming a healthy diet. Considering the prevalence of diabetes in Jamaica, the identification of drinks and other foods with low GI and GL may be useful to health care providers and nutritionists when giving dietary guidance to patients. Consumption of low GI beverages and snacks may aid in better management or prevention of chronic diseases such as type 2 diabetes mellitus and obesity [29,30].

Conclusion

This study provides scientific evidence of the glucose response of the formulated vegetable drink. This low GI and GL of the vegetable drink may be useful for diabetic patients as well as healthy individuals that are seeking a healthy alternative to the high carbohydrate beverages currently available in Jamaica. The availability of low GI and GL drinks, foods or snacks in the Jamaican market may aid in preventing or better management diabetes and its associated metabolic disorders.

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