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Glycemic Index of Selected Foods in Jamaica

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Abstract

Background: Fruits, vegetables and legumes for their complex carbohydrates, dietary fiber and micronutrients, should form an essential part of every diet. In order to give good dietary advice to diabetic patients, it is necessary to know the glycemic index of foods commonly consumed locally. The objective of this study was to determine the Glycemic Index (GI) and Glycemic Load (GL) of commonly available and consumed Guava (*Psidium guajava*), Watermelon (*Citrullus vulgaris*), Gungo (*Cajanus cajan*), Papaya (*Carica papaya*) and tomato (*Solanum lycopersicum*) in Jamaica.

Methods: Ten (10) healthy Jamaican subjects (5 males, 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 50 (or 25) grams of available carbohydrate portions of glucose (standard food) and test foods after an overnight fast and their serum glucose levels were determined at 0, 15, 30, 45, 60, 90 and 120 minutes after the consumption of each test food. Glucose was tested on three separate occasions, and the test foods once. The GI value was calculated geometrically by expressing the Incremental Area Under the Blood Glucose Curve (IAUC) for the test foods as a percentage of each subject's average IAUC for the standard food.

Results: The results indicated that the IAUC for Watermelon (95 ± 11) was significantly higher ($p<0.05$) than that of Tomato (37 ± 12), and Gungo (58 ± 13). The differences in IAUC of Watermelon (95 ± 11), Guava (83 ± 27) and Papaya (80 ± 7) were not statistically significant. Similarly, there was no significant difference in GI among the samples studied.

Conclusion: Tomato, Gungo, Papaya Watermelon and Guava were shown to have low glycemic index and glycemic load values.

Keywords: Glycemic index, Glycemic load, Diabetes, Glucose

Abbreviations: GI-Glycemic Indices, NCDs-Non-Communicable Diseases, GL-Glycemic Load, IAUC-Incremental Areas under the Curve

Introduction

The prevalence of chronic Non-Communicable Diseases (NCDs) are increasing globally and triggering untimely deaths due to changes in diet and lifestyle. Therefore, effective strategies for prevention and controlling the spread of these diseases are of absolute importance [1-3]. It is often reported that increased consumption of dietary fiber may lead to better control and management of diabetes mellitus, cancer and cardiovascular diseases. The physical and chemical profiles of dietary fiber, such as, fibrous structure and viscosity have a major role in the digestion and absorption of nutrients, despite the amount of available carbohydrates [4].

The effect a carbohydrate has on post-prandial blood glucose concentration is best described by its Glycemic Indices (GI). The concept of dietary GI was first reported as a factor that should be managed to prevent chronic diseases, more than three decades ago by researchers at the University of Toronto, Canada [5]. GI can be defined as a relative ranking of carbohydrates in foods on a scale of 0 to 100, based on the extent to which they increase blood glucose levels after consumption [5-8]. 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 take a relatively longer time to break down and release glucose slowly into the bloodstream are referred to as low GI (GI ≤ 55) foods index [5,9-12]. Further, it is important to know that both the quantity and the quality of carbohydrates may affect blood glucose response; this is documented as the glycemic load [5,8]. Glycemic Load (GL) investigates the total impact of the dietary carbohydrates on blood glucose level after a meal. The glycemic load is computed by determining 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) [10,13,14]. It is recommended that the GL should be considered when guiding individuals in making healthy food choices [3,6,15-17].

The higher the GL of the food, the greater the rise of blood glucose and insulin levels. Long-term consumption of a high GL diet has been linked with increased risk of type 2 diabetes and related complications [10,16,18,19]. Research has shown that consuming low GI foods is a possible inexpensive dietary alternative in the management of diabetes [6,8,20,21]. The nutritional benefits of fruits, vegetables and legumes make them a good choice for weight and health management [3,22]. Therefore, it is important that the GI and GL of our fruits, vegetables and legumes be determined to better guide the choices of the consumer. This study investigated the glycemic index and glycemic load of commonly available and consumed fruits, vegetables and legumes in Jamaica.

Materials and Methods

Food samples

Freshly harvested, Guava (*Psidium guajava*), Watermelon (*Citrullus vulgaris*), Tomato (*Solanum lycopersicum*), Gungo (*Cajanus cajan*) and Papaya (*Carica papaya*) were sourced from a local market in Kingston, Jamaica.

Methods

Adult Jamaican subjects between the ages of 25 to 45 years were recruited among the students and staffs of the University of the West Indies (Mona Campus). Ten healthy subjects, with an active lifestyle, not using any prescribed medication and without any diagnosed diseases were selected for study. Exclusion criteria were as follows: Smokers, overweight, obese, diabetic individuals and pregnant or lactating women. Proximate analysis for carbohydrate, fat, crude protein, moisture, dietary fiber content and ash were determined using the AOAC (2002) standard. Total carbohydrate was done by difference according to FAO/WHO Expert Consultation protocol (Food and Agriculture Organization & World Health Organization, 1998). Proportion of fruits equivalent to 50 (or 25) grams of available carbohydrate was fed to subjects after an overnight fast and their serum glucose levels were determined at 0, 15, 30, 45, 60, 90 and 120 minutes for each test food on different days during the study.

The Incremental Areas under the Curve (IAUC) were calculated according to the method of Brouns et al. [13]. Pure glucose 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 [23]. 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 (Ethical approval number: AN 14, 12/13).

Statistical analysis

Data obtained from the experiments are expressed as mean ± SE. Differences between the control and the treatments in the experiments were analyzed using ANOVA and Duncan's multiple range tests, while values of $P \leq 0.05$ were considered significant.

Results

The 10 Jamaican subjects, comprising five (5) males and five (5) females were between ages 25 and 45 years with a mean age of 30 ± 2 years and BMI 25 ± 1 kg/m^2. **Table 1** represents the proximate compositions of the foods studied. Gungo was found to have the highest crude protein content (5.4 [g/100g]), while Watermelon had the lowest (0.02 [g/100g]). The crude protein content of the other samples ranged from 0.04 to 1.14 [g/100g].

Samples	% Crude Protein	% Ash	% Moisture	% Total Sugars	% Crude Fiber	% Carbohydrate
Watermelon	0.02	ND	91.5	4.94	0.14	7.51
Gungo	5.4	0.66	73.2	ND	2.37	20.1
Papaya	0.04	0.33	87	9.4	0.36	1.04
Tomato	1.14	0.36	94.3	2.2	0.59	4.2
Guava	0.59	0.55	84.15	4.16	4.42	14.71

ND – Not Determined

Table 1: Proximate composition of five food samples (100g) studied.

Food	GI	GI ranking	GL	GL ranking	IAUC	Glucose standard
Tomato	23±11	Low	1.6	Low	$37±12^{a}$	184±29
Gungo	43±12	Low	6.2	Low	$58±13^{ab}$	179±30
Papaya	46±6	Low	4.6	Low	$80±7^{ab}$	204±34
Watermelon	50±6	Low	5	Low	$95±11^{b}$	207±26
Guava	54±15	Low	5.4	Low	$83±27^{b}$	154±31

Subscripts with different letters are significantly different (P< 0.05) Values are mean ± SE for n = 10 subjects

Glycemic Iindex (GI) for each sample was calculated by expressing the IAUC as a percentage of the mean response area of glucose as outlined by Brouns et al.

Table 2: Glycemic indices and incremental areas under the glucose response curve (IAUC) for eight food samples studied.

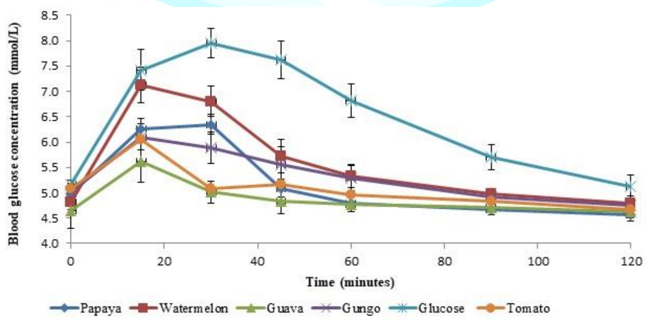

Figure 1: Mean glycemic response elicited by 50g available carbohydrate portions of Papaya (*Carica papaya*), Watermelon (*Citrullus vulgaris*), Guava (*Psidium guajava*), Gungo (*Cajanus cajan*), Tomato (*Solanum lycopersicum*) and glucose reference food.
Values represented as mean ± SE for n = 10 subjects.

The moisture content of the foods was highest in Tomato (94.3%) and lowest in Gungo (73.2%). Papaya was found to have the highest total sugars (9.4%) and Tomato the lowest (2.2%). Crude fiber content was highest in Guava (4.42%), while Watermelon had the lowest crude fiber content of 0.14%. The carbohydrate content of the food samples ranged from 1.04 [g/100g] to 20.10 [g/100g] with Papaya having the lowest and Gungo the highest content. **Table 2** shows the GI values of the food samples determined relative to the reference food (glucose GI=100) and categorized as high (70 to 100), intermediate (56 to 69), or low (<55). The GI of the test food samples ranged from 23 ± 11 to 54 ± 15. Tomato was observed to have the lowest of 23 ± 11; this was followed by Gungo with a value of 43 ± 12. The highest GI was observed in Guava (54 ± 15). Similarly, the GL (high ≥ 20, medium 11-19 and low ≤ 10) ranged from 1.6 to 6.2. Tomato was observed to have the lowest GL of 1.6 and the highest GL was observed in Gungo (6.2). In addition, Watermelon showed the highest incremental area under (IAUC) the glucose response curve of 95 ± 11 and Tomato the lowest with 37 ± 12. **Figure 1** illustrates the mean glucose responses of the five food samples studied. The blood glucose response to the food samples increased with time, reaching their peak at approximately 15 minutes except for Papaya that peaked at 30 minutes, after which a decline in the response with increasing time was observed.

Discussion

It has long been recognized that “not all carbohydrates are created equal” with regard to their effects on glucose metabolism and insulin action [24,25]. Furthermore, it is understood that different complex carbohydrates could have different physiological effects. Food with high GI is reported to have a deleterious effect on health and therefore should be avoided [1,3].

This study was done to determine the glycemic indices of three fruits, a vegetable and a legume that are frequently consumed in the Caribbean, thus contributing to the Caribbean Glycemic Index Database. The glycemic indices of the selected foods ranged from 23 to 54 **(Table 2)**. The results showed that at fixed quantities of available carbohydrates, there were distinct variations in the glucose response. This supports the knowledge that equal carbohydrate portions of different foods can display different glycemic response on human subjects [25]. To give good dietary guidance, it is important to know the glycemic index of the food consumed in different ethnic groups. In this study the GI (54) and GL (5.4) of Guava was determined to be low. Similar findings were documented in Brazil, where researchers reported low GI (12) and GL (1.1) of Guava samples studied [3]. Further, the legume Black-eyed beans (Cowpeas) were documented to have low GI (34) and GL (10) in a study conducted in Canada [5], while researchers Sabeetha, Nisak and Barakatun [26] determined the GI of Watermelon to be low (51) which is consistent with the findings of this and other studies conducted [27]. However, in Australia the GI (56) of Papaya was reported to be medium and GL (5) low in work done by researchers Miller et al., while in this study the GI (46) and GL (4.6) of Papaya were both determined as low.

It is important to mention that the GI values of the same type of fruits cultivated in different geographical location may vary and could be due to the environmental conditions or difference in sugar composition, fiber content, stage of ripening, acid content, method of storage and harvesting or it could be the methods used to determine the GI of the test foods [3,27-29]. Tomato had the lowest GI and AUC (23 ± 11 and 37 ± 12 respectively), this could be due to the fiber content. The dietary fiber could influence the digestion and adsorption of the carbohydrate present and thereby influence blood glucose response [30,31]. In **Figure 1**, the test foods displayed a high initial peak at approximately 15 minutes, followed by a gradual decrease in blood glucose. The relatively low glucose peak displayed by Tomato, Gungo and Papaya may be promising results in terms of their recommendation to patients with diabetes and its associated metabolic dysfunctions or other NCDs [3,6,8,21].

Conclusion

From the present study, the glycemic index of Tomato (23), Gungo (43) and Papaya (46), Watermelon (50) and Guava (54) were shown to have low glycemic index and glycemic load values. It is reported that reduce consumption of high GI foods and increase the intake of low and intermediate GI may lead to better management of diabetes, coronary heart disease and obesity [10,11]. Therefore, it is important that low and intermediate GI foods be identified, and their consumption recommended.

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