Glycemic Index for Sucrose, Corn Syrup and Honey Entrained Highbush Cranberry Juice

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Abstract:
Glycemic Index (GI) is a measure of the effect foods have on blood glucose (i.e., blood sugar). In this study, it was aimed to find out the GI of high bush cranberry juice (HCJ) in four forms of use (juice with no added sugar and juice sweetened with corn syrup, sucrose or honey) based on data from a total of 20 healthy volunteers.

After not eating for 12 hours and consuming the test foods and the reference food, the participants were subject to blood drawing by automatic lancet, 15, 30, 45, 60, 90, and 120 minutes into the application. GI values of HCJ samples were found by calculating incremental areas for each individual. GI of HCJ with no added sugar had the lowest value (40.95), followed by that of the sucrose added HCJ (42.75). GIs of HCJ with corn syrup and honey were found to be similar, 54.16 and 56.98, respectively. Moreover, those with no added sugar and those with sucrose and corn syrup fell into the low GI category, while the GI of HCJ with honey fell into the medium GI category. In conclusion, it is suggested that consuming HCJ with low GI values might be a healthier choice for individuals with chronic illnesses.

Keywords: Glycemic index, high bush cranberry juice, sucrose, corn syrup, honey.

1. Introduction:
Research shows that carbohydrate sources have different effects on blood sugar and insulin secretion [1,2]. With the presence of such an effect, the term Glycemic Index (GI) has become a current topic for assessing the effect of different sources of carbohydrates on blood glucose levels [3,4].

In recent years, the relation between GIs of food items and their effects on body and health has gained importance to a great extent. It is important to know GIs of foods when administering diet therapy and selecting healthy diets in many chronic illnesses. For this reason, most doctors and dietitians suggest that, in addition to consuming sufficient and balanced nutrition, one should also consume food items with low GIs to adhere to a healthy diet.

Different countries are in an effort to determine the GIs of food items they produce. International Tables of GI were prepared in 1995, 2002 and 2008, and GI values of more than three thousand nutrients were determined [5,6]. GI values of essential nutrients such as milk and yogurt are generally the same, but GI values of fruit and fruit juice vary. How fruit varieties and fruit are consumed also changes their GI values. For example, when glucose
is taken as a reference nutrient, the GIs of pear, plum, pineapple and watermelon are 38, 39, 59 and 72, respectively. Grapefruit has a GI of 25, while grapefruit juice has that of 48; dried apricots, fresh apricots, and canned apricots have GI values of 31, 57 and 64, respectively [7]. It is also important to identify regional GI values, as there may be differences in the composition of food items [6].

Highbush cranberry, within the family Caprifoliaceae (*Viburnum opulus*), is a fruit native to Anatolia. Highbush cranberry, after being picked in September–October, is soaked in water for one–three months. Its juice is traditionally produced at homes or technologically in factories by flavoring with different types of sugar such as sucrose, corn syrup and honey. Highbush cranberry juice (HCJ) is traditionally used for the treatment and prevention of kidney diseases, gall bladder and liver diseases, and diabetes. It is also used for pain and cramp relief, as well as the improvement of general health.

Our country, Turkey, is one of the most important countries of the world in beekeeping thanks to its rich and highly varied flora. Honey that is found in our dining tables as a sweetener is not only a valuable nutrient in our country but also a medical product favored for health. The International Tables of GI lists honey as having GIs that range from 32 to 87, depending on the botanical origin and fructose content [5].

While there is little information about physical and chemical features of HCJ, there is no scientific information about its GI. Therefore, in this study, it was aimed to find out the GI of this regional juice, HCJ, and the GIs of HCJ with different types of sweeteners (sucrose, corn syrup, and honey). The aim of the study was also to provide producers and consumers with information on HCJ-related healthy diets by comparing the results.

2. Materials and Methods:

2.1. High bush cranberry samples:

Highbush cranberries to be used in this study were picked between September and October in 2014 in İncesu, Bünyan and Akkışla, cities of Kayseri province where they grow and are produced the most. Four different samples of HCJ with a soaked weight of at least 30 kg each were purchased. Carbohydrate contents of the highbush cranberries were determined at the Technological Research and Application Laboratory of Erciyes University. The HCJ sample with a carbohydrate value nearest to the mean carbohydrate value was selected for the study.

2.2. Sucrose, corn syrup and citrus honey:

The HCJ sample that was sweetened with *corn syrup* were bought from a business firm. The corn syrup contained 55% fructose, 42–44% glucose, and 1–3% polysaccharide (glucose polymers). *Citrus honey* that was used in the study was bought directly from an apiarist, and its GI value had already been detected by Atalay et al. as 44.9 [8]. The common table sugar was used as the source of sucrose.

2.3. Carbohydrate analysis of HCJ:

Carbohydrate analyses of the HCJ were carried out using the HPLC technique, specifically by using an Agilent 1260 Series LC (Degasser, pomp, automatic sampler, column furnace, and fluorometric detector), EC Nucleosil (150 mm × 4.6 mm, 5 μm, NH2) (Macherey Nagel), and a column (Mobile phase: Water: Acetonitrile (25:75), flow rate 1 mL/min., Column heat 30°C, Detector: Reflector index (RI), Injection amount: 20 μL, Analysis period 15 min). A sample of 0.1 g from each of the fructose, glucose and sucrose were weighed and dissolved in 10 mL super pure water (final density 10 mg/mL), and from those solutions, a standard curve with a mean value of 3, within 2.5 and 6.6 mg/mL dilutions. Next, 0.25 g highbush cranberry was weighed with 2 m capped tubes and 1.5 mL acetonitrile. Water (50:50) was added and vortexed for 20 seconds, and the tubes were centrifuged for 5 min. at 12,000 cycles. After filtering the liquid part using 0.20 μ filters, a 20 μL volume of this material was subject to the HPLC, and sugar levels were determined. In the samples, the sugar analyses were carried out according to the HPLC and the DIN 10758 method (DIN 10758: Untersuchung von Honig – Bestimmung des Gehaltes an den Sacchariden Fructose, Glucose, Saccharose, Turanose und Maltose HPLC-Verfahren). For this purpose, a Waters and Alliance model HPLC system was used, where reactive index detector amin modified 4 ort h gel column (3 × 100 mm). The method was implemented with the following chromatographic conditions — mobile phase: acetonitrile/water (80/20), column temperature: 35 °C, and flow rate: 0.5 mL/minutes [9].

2.4. Research Sample:

The permission for the study was granted by the Clinical Studies Ethical Review Board of Erciyes
University (with decision no. 2013/642 dated 11.22.2013). Research sample consisted of 20 healthy volunteer students from Nuh Naci Yazgan University. Students who had a Body Mass Index (BMI) higher than 30, regularly used pills, had diabetes history in their family, had any chronic illness and had been on a diet for any reasons were not included in the study. Having 10 participants in each group has a power of 80% to predict results at the 0.05 level, and this level has 3 mean magnitude for glycemic index studies [10].

2.5. Application:
The participants were instructed to avoid eating or exercising excessively, to consume only 300 g carbohydrate all day, and not to consume alcohol one day prior to the test. Beginning with the night before the test, the volunteers fasted for 10–12 h after dinner and drank only water during their fasting period.

2.5.1. Reference food applications:
The reference food was tested twice, within different weeks.

Glikosol® (330 ml), which consists of 50 g glucose, was used as the reference food.

2.5.2. Test food applications:
Based on the analysis results, HCJ with 50 gr of carbohydrate was administered as the test food in four different forms during different weeks, as follows:

HCJ-Corn Syrup: Highbush cranberry juice with 10.2% corn syrup,

HCJ-Sucrose: Highbush cranberry juice with 10.2% (31.1 g) sucrose,

HCJ: Highbush cranberry juice with not added flavor or sugar

HCJ-Honey: Highbush cranberry juice with 10.2% (35 g) citrus honey.

2.6. Determination of Glycemic Index:
In this study, the GI values of HCJ were determined in accordance with the procedures that have been well-established in the GI literature [10, 11, 12]. Blood samples were taken from the finger using an automatic lancet (Safe-T-Pro, Germany) 15, 30, 45, 60, 90, and 120 min into the application, and each time the amount of glucose was determined by a glucometer. The GI was calculated as the percent of glycemic area determined after the consumption of HCJ to the glycemic area produced by the glucose that was chosen as the standard [13]. The commonly-used GI classification system categorizes food into 3 groups, as low (<55), medium (55–69) or high GI (>70) [11]. The HCJ samples in this study were classified according to the GI results.

2.7. Statistical Analysis:
All data gathered at the end of the study were evaluated using SPSS (Statistical Package for the Social Sciences) under the supervision of academicians from Erciyes University, Faculty of Medicine, Department of Biostatistics and Medical Informatics. Whether the data were normally distributed was checked using visual methods (histograms and probability graphs) and the Shapiro-Wilk test, one of the analytical methods. Because the GI values of the test food showed normal distribution, defining analyses were given with using mean and standard deviations. In all statistical tests, results with p<0.05 were considered statistically significant [14].

3. Results:
The HCJ that was used in the study had 3.24% fructose, 3.36% glucose, 0.08% sucrose and 0.21% maltose content, while honey with a high amount of carbohydrate content had 36.9% fructose, 29.5% glucose, 2.6% sucrose and 2.6% maltose content (Table1).

Table1. Digestible carbohydrate contents of HCJ* and honey

<table>
<thead>
<tr>
<th>SAMPLES</th>
<th>Fructose</th>
<th>Glucose</th>
<th>Sucrose</th>
<th>Maltose</th>
<th>Total CHO</th>
</tr>
</thead>
<tbody>
<tr>
<td>HCJ</td>
<td>3.24</td>
<td>3.36</td>
<td>0.08</td>
<td>0.21</td>
<td>6.91</td>
</tr>
<tr>
<td>Citrus honey</td>
<td>36.9</td>
<td>29.5</td>
<td>2.6</td>
<td>2.6</td>
<td>82</td>
</tr>
</tbody>
</table>

*HCJ: Highbush Cranberry Juice

The GI of HCJ with no added sugar had the lowest value (40.95), followed by that of HCJ with sucrose (42.75). The GI values of HCJ with fructose and HCJ with honey were found to be similar, 54.16 and 56.98, respectively, but the former was in the low
GI category, whereas the latter was in the medium GI category (Table 2).

**Table 2. Glycemic and upper incremental index values of HCJ**

<table>
<thead>
<tr>
<th>Samples</th>
<th>GI</th>
<th>Min</th>
<th>Max</th>
<th>GI Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>HCl-Corn syrup</td>
<td>54.16±22.72</td>
<td>17.33</td>
<td>115.71</td>
<td>Low</td>
</tr>
<tr>
<td>HCl-Sucrose</td>
<td>42.75±23.96</td>
<td>10.49</td>
<td>112.24</td>
<td>Low</td>
</tr>
<tr>
<td>HCl</td>
<td>40.95±23.07</td>
<td>8.72</td>
<td>80.41</td>
<td>Low</td>
</tr>
<tr>
<td>HCl-Honey</td>
<td>56.98±26.17</td>
<td>20.42</td>
<td>109.30</td>
<td>Medium</td>
</tr>
</tbody>
</table>

*HCJ: Highbush Cranberry Juice*

However, as expected, HCJ, which was with no added sugar at all times, increased blood sugar the least, while the HCJ containing corn syrup increased it the highest at the 30th minute (Figure 1).

![Figure 1. Changes in blood glucose level after the reference food and the HCJ](image)

4. Discussion:

The relationship between GI, chronic illnesses and protection of health has been one of issues that has been studied extensively. FAO/WHO Specialist Committee specified the observation of GI as the most important method for the maintenance of health and treatment of chronic illness [15].

In our country, however, there is little data on the GI values of food items. Only the GI values of certain types of bread, pasta, rice and potato have been determined in the studies that have been carried out [16, 17]. In this first scientific study where the GI was determined in the fruit category in our country, the GI of the traditional type sugar-free HCJ, which is frequently consumed in the Central Anatolia Region, was found to be 40.95. Based on this result, HCJ has a low GI.

Oboh et al. examined the GI of thirteen different fruits grown in the Nigerian region [18]. They found that the GI values of African star apples, guavas, cashews, soursops and carrots were low (28.01, 32.25, 31.60, 30.33, and 35.86, respectively). However, they said that these results may differ from the GI values of the fruits grown in other countries.

Fructose is natural sugar, found in fruits and honey. It’s important sources are sucrose and high fructose corn syrup (HFCS) that added to foods and beverages.

The main area where corn syrup is used is the carbonated drinks, followed by all flavored drinks (juices, ice teas, juiced mineral waters, etc.), chocolate, cake, candy types, jam, marmalade and other jelly type foods [19]. In the past, fructose, naturally found in fruits, became the most used flavoring item within the food industry. It has been reported in a study that since the time corn syrup production began commercially, fructose consumption has increased rapidly however the consumption of naturally-produced fructose remained the same. Recent studies indicate that increasing in the intake of fructose parallels to the increasing in type 2 diabetes and obesity. Despite recent reports point out the association of high fructose intake with several diseases, it should be noted that not all the fructose source has the same effect. Since there are limited number of human studies examining the relationship between health and fructose, plus the study concentrations are quite high, it is difficult to directly relate these studies with human health[20]

In order to facilitate and increase HCJ consumption, a sugar-added form of it has also been produced in the food industry, and it is being consumed with sugar at homes using traditional methods, as well. In this study, adding sucrose, corn syrup and honey increased the GI value of HCJ. Within the tested samples, the GI values of HCJ with corn syrup and HCJ with honey were closer.

HCJ with honey had a medium level GI. Dried form of honey consists of carbohydrates 95% fructose and glucose. 5–10% of total carbohydrates are...
oligosaccharide, and overall, there are 25 different disaccharides and trisaccharides [21]. Honey with its useful antimicrobial, antioxidant, antiradical, etc. features is not only used as sweetener, but also as a traditional medicine [22]. Bogdanov et al. stated that certain types of honey have higher amounts of concentrated fructose and lower levels of GI when compared to other types of honey [21]. There are lots of studies on the effects of honey and sugar in honey (glucose, fructose and sucrose) on GI. Foster-Powell et al. stated that in the international table of GI and glycemic load values, honey has a lower GI value than sucrose (0.55±0.05 and 1.10±0.21, respectively) [5]. It was also shown that honey has lower GIs in children (adolescence, mean age 10.95) [23, 24]. In a study conducted by Atalay et al., the GI of citrus honey used in the study was found to be 44.9 and classified as low [8].

Both controversy and confusion exist concerning fructose, sucrose, and high-fructose corn syrup (HFCS) with respect to their metabolism and health effects. Whether there is a link between fructose, HFCS, or sucrose and increased risk of heart disease, metabolic syndrome, or fatty infiltration of the liver or muscle remains in dispute with different studies using different methodologies arriving at different conclusions. [25].

In health policies and nutritional suggestions of many countries, it is stated that sugar consumption must be limited [26, 27]. WHO recommended a reduced intake of free sugars throughout the lifecourse, reducing the intake of free sugars to less than 10% of total energy intake, WHO suggests a further reduction of the intake of free sugars to below 5% of total energy intake [28].

**Conclusion:**

In this study, the HCJ samples, in this study, were found to be in the low and medium GI category. The GI of HCJ with no added sugar was found as 40.95. This result shows that HCJ has a low GI. The other HCJ samples with corn syrup and those with honey were found to have higher GI values. The consumption of the sugar-free form of HCJ with lower GI commonly preferred by people with chronic diseases can be considered as a healthier choice for people with obesity, especially with diabetes and heart disease. In future research, it might be useful to examine the responses of patients especially with impaired glucose tolerance and diabetes to foods with low glycemic index.

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