Acta Scientiarum

http://periodicos.uem.br/ojs/acta
ISSN on-line: 1807-8648
Doi: 10.4025/actascihealthsci.v46i1.66222

CIÊNCIAS DA SAÚDE / HEALTH SCIENCES

Comparison of glycaemic index of honey and sports energy products

Nives Brekalo and Ines Banjari*

Department of Food and Nutrition Research, Faculty of Food Technology Osijek, Josip Juraj Strossmayer University of Osijek, F. Kuhača 18, 31000 Osijek, Croatia. *Author for correspondence. E-mail: ibanjari@ptfos.hr

ABSTRACT. Consumers' interest towards glycaemic index (GI) is expanding due to their aspiration towards informed buying and increased awareness regarding diet. This is especially the case for people engaged in various physical activities. Their diet, besides general principles of a healthy balanced diet, should also meet the needs of training. Consumption of carbohydrates with different GI before, during and after training affects athletic performance, with high GI food being preferred. The aim was to compare the effect of honey and two different sports energy products on glycaemia and their potential in terms of sports performance. GI of acacia honey and two sports energy products (gel and jelly) was determined according to the method ISO 26642: 2010. Ten healthy males aged 23.2 years (20 to 27 years old) who are minimum 4 hours per week engaged in at least one sport were enrolled. Glycaemia was the least affected by honey (GI = 89.6 ± 37.1), while jelly increased glycaemia the most (GI = 162.1 ± 60.9), and the difference was statistically significant ($p = 0.008$). Honey also showed good acceptability, and did not differ in subjective satiety score to gel or jelly. The results show that honey can be a good alternative to various sports energy products, and a more affordable one.

Keywords: glycaemic index; sport performance; honey; sports energy products.

Received on December8, 2022.
Accepted on August 8, 2023.

Introduction

A series of research conducted in the early eighties of the 20th century found that consuming carbohydrates could improve exercise capacity during long-term training and competition. In order to achieve maximum impact strength, optimal amount, type and right time for the consumption of carbohydrates needed to be determined (Donaldson, Perry, & Rose, 2010). Thirty years ago, the concept of the glycaemic index (GI) was developed as identification of the physiological dimension of both quality and classification of carbohydrates (Brand-Miller & Buyken, 2020). However, not even until the early nineties of the 20th century the importance of GI in optimizing athletic performance has not been recognized. The role of food with a high GI (HGI) and low GI (LGI) respectively, in the diet of athletes is still under discussion (Cermak & Loon, 2013). Due to the recovery and improvement of the impact strength today is generally accepted that is important to consume carbohydrates before, during and after exercise (Donaldson et al., 2010). Sports energy products followed success of sports drinks. Their intended purpose is to provide much higher amount of carbohydrates per unit (in comparison to drinks), while increasing endurance performance and decreasing gastrointestinal problems (Jonvik, King, Rollo, Stellingwerff, & Pitsiladis, 2022).

Food GI is affected by chemical and physical properties of the food, with the possibility of large individual variation depending on sex and type of exercise (Atkinson, Brand-Miller, Foster-Powell, Buyken, & Goletzke, 2021). Uptake of glucose during exercise increases by up to 50-fold (Sylow, Kleinert, Richter, & Jensen, 2017), emphasizing the importance of proper selection of carbohydrates. In other words, exercise will alter glycaemic response to carbohydrates (Lambert, 2018). Generally, consumption of carbohydrates with different GI before, during and after training is considered as significant effector of the athletic performance (O'Reilly, Wong, & Chen, 2017).

Nowadays, due to increased interest of consumers towards informed buying and interest towards nutritional profile of foods they eat, honey is considered as a more favourable sweetener, which is well tolerated, especially Acacia honey (Hills, Mitchell, Wells, & Russell, 2019). In comparison to sports gels, on the basis of carbohydrate composition, honey shows better results on cycling endurance (Earnest et al., 2004).

The aim was to compare commercially available sports energy products and honey according to their GI and to determine their potential to improve athletic performance.

Subjects and methods

Study subjects

The main inclusion criteria were absence of a diagnosis related to elevated glycaemia (i.e. diabetes, prediabetes or any other related to impaired glycaemia) and intensive physical activity in leisure time, measured through body composition and physical activity questionnaire (Baecke, Burema, & Frijters, 1982). Healthy males of minimum 18 years of age, who are actively involved in sports at leisure time (at least 4 hours a week), came for an interview to introduce them with the study protocol. Informed consent procedure preceded signing of the consent for by all study subjects.

The number of subjects required for the study was determined by the power analysis method (minimum strength of 80%, with minimal glucose change for the same subject of 0.20 mmol L^{-1}). In order to satisfy the strength of the study, minimum of ten subjects was required.

Subjects were asked to come for the second appointment after a minimum of 8 to 10 hours of fasting, for screening. They completed a general questionnaire on basic and socio-economic characteristics, Baecke's physical activity questionnaire (Baecke et al., 1982), and anthropometric and body composition was measured by Tanita MC-180 analyser. After analysing the results on their medical history, physical activity level and anthropometric data, ten subjects were selected for the study. They received detailed information on the protocol and appointments.

Test foods

Four foods with a known carbohydrate composition were tested:

1. Gel (Multipower® Multicarbo gel);
2. Jelly (Multipower® Multicarbo jelly);
3. Acacia honey;
4. Control (glucose) (Table 1).

The food was prepared professionally in the expected quality and quantity, according to the manufacturer's instructions. Foods were freshly prepared, each day. Each serving contained 50 g of digestible carbohydrates. Glucose was dissolved in 250 mL of clear apple juice.

Table 1. Energy and nutrition profile of the tested foods (per serving).

	Gel (serving size 40 g)	Jelly (serving size 100 g)	Honey (per 100 g)	Control (per 100 mL)
Calories (kJ $kcal^{-1}$)	442/104	1017/239	1339/320	197/47
Total Carbohydrate (g)	26	58	80	11.7
Sugars (g)	10	56	80	11.5
Proteins (g)	< 0.1	< 0.1	-	0.1
Fats (g)	< 0.1	< 0.1	-	0.1
Saturated fats (g)	< 0.1	< 0.1	-	-
Fibers (g)	< 0.1	2.3	-	0.2
Vitamin C (mg)	-	-	4	1
Thiamin (mg)	-	-	-	0.02
Riboflavin (mg)	-	-	0.02	0.02
Niacin (mg)	-	-	0.1	0.1
Vitamin B_6 (mg)	-	-	0.03	0.03
Magnesium (mg)	-	-	2	7
Sodium (mg)	140	100	10	3
Potassium (mg)	140	-	50	119
Calcium (mg)	-	-	5	-
Copper (mg)	-	-	0.05	-
Phosphorus (mg)	-	-	20	-

Study design

Glycaemic index (GI) for the two commercially available energy products and honey was done according to ISO 26 642:2010 method (International Standards Organization [ISO], 2010). The Ethics Committee for research on humans of the Faculty of Food Technology Osijek approved the study.

Randomization was done by an independent person, which had no contact with the study subjects or study investigators.

For every study appointment, subjects came after an 8 to 10 hours of fasting. They were given a glucometer (Bayer CONTOUR USB NEXT), lancets and strips (all Bayer) to use during the study protocol. Blood samples were taken at the following time points: five minutes before the start, 0', 15', 30', 45', 60', 90', 120'. Test food was given between time points 0' and 15', and subjects were asked to consume test food within 10 minutes. After consuming test food they were asked to subjectively grade how much did they liked the food, i.e. to assess the sensory acceptability of the food by using the hedonic scale. Also, between every blood sampling, subjects were asked to fill in the form of side-effects, and the satiety questionnaire.

Statistical analysis

Postprandial blood glucose was used to calculate incremental Area Under the blood glucose response Curve (iAUC) by using the trapezoid method. Afterwards, iAUC was used to calculate GI for the two test samples, according to formula (ISO, 2010):

$$\mathrm{GI} = \frac{\mathrm{iAUC\ t}}{\mathrm{iAUC\ con}} * 100$$

iAUC t – incremental Area Under the blood glucose response Curve for the test food
iAUC con – incremental Area Under the blood glucose response Curve for the standard (control).

Test foods were tested for sensory acceptability, i.e. palatability. Hedonic scale was used, ranging from score 1 (‘I like it very much’) to score 7 (‘I extremely don’t like it’).

The satiety questionnaire consists of four visual analogue scales asking a subject to subjectively rate feeling of hunger, desire to eat, prospective consumption, and fullness, respectively. Extreme left point reflects the feeling of complete satiety for the concerned descriptor, except for the third scale, in the other direction. Then the rates are measured and combined at each observed time point into a total subjective appetite score using the formula:

$$\frac{(Q1 + Q2 + (100 - Q3) + Q4)}{4}$$

Data were analysed by MS Office Excel 2016 (Microsoft Corp., USA) and Statistica 14.0 (StatSoft Inc., USA). Parametric tests were used, i.e. t-test for independent and dependent variables, and Pearson’s correlation test, with the level of significance p = 0.05. All data are given as average and standard deviation (± SD).

Results and discussion

Subjects’ characteristics

Study encompassed 10 healthy males, average age 23.3 years (20-27 years). Eight subjects are full-time students, two are full-time employed, none of the subjects have children, and their average monthly income is 330-460 EUR/person. Two subjects smoke, all subjects rarely consume alcohol (on a monthly basis) and drink an average of 1.5-2 litres of water per day. Four subjects were taking dietary supplements (two subjects were taking protein shakes and two were taking vitamin B and C).

The level of physical activity was assessed through three dimensions, by using Baecke’s activity questionnaire. Determined physical activity indexes were: work index 2.3 (± 0.5), sport index 2.9 (± 2.6) and leisure index 2.9 (± 0.9). Previous study, by using the same questionnaire, found higher indexes for people engaged in intensive sports (Karas, Banjari, & Kenjerić, 2015). Body composition analysis is in accordance with the determined physical activity indexes, and all study subject fall within the inclusion criteria, i.e. to a category of very active amateurs (Baecke et al., 1982).

Acceptability and satiety

Besides determining the GI, sensory acceptability was also evaluated. Acceptability is an important aspect when testing consumer’s preference towards specific products. Out of all tested samples, the lowest preference had Gel (3.2 ± 1.1; p = 0.005 vs the Control). Control sample had the highest preference, which can be explained by recognition and familiarity with the taste of clear apple juice which was used as a basis for Control (1.7 ± 0.9).

The subjective feeling of satiety is directly related to the type of consumed meal as well as its composition. It is important to point out that a meal viscosity presents a significant determinant of subjective satiety; solid food causes greater satiety than liquid food or beverage, which is directly related to the physiology and the process of digestion (Wolever, 2006; Orrù i sur., 2018).

There was no statistically significant difference in subjective satiety between any of the samples at any time point. Such results were expected due to carbohydrate composition of the samples, and it is considered as a positive feature. This confirms the intended purpose of the samples, and honey can be considered as a potentially good alternative to commercial products for the increase of athletic performance.

Importantly, no severe side effects were noted during the study. Only one subject felt mild inflation from fluid after consuming Jelly.

Glycaemic index

The speed and the intensity of blood glucose increase after eating a certain meal compared to the standard represents GI (Wolever, 2006). The amplitude of the increase in blood glucose determines the amount of secreted insulin, and is in direct relation with a number of metabolic disorders, from obesity, diabetes, metabolic syndrome, and others (Blaak et al., 2012). From the aspect of sports performance, the importance is even greater (Sparks et al., 2021; Sylow et al., 2017).

GI is defined as a relationship of incremental or total area under the curve in response to blood glucose of tested food (iAUC) containing 50 grams of free carbohydrates and total area under the curve in response to blood glucose of standard test food (iAUCS). Area under the curve for the test samples was calculated as the sum of the areas of a trapezoid under the glucose concentration curves for the tested samplesand expressed in 120 mmol x min L^{-1}. The calculated iAUC values are as follows: honey 81.0 ± 8.6; control 100.3 ± 13.1; gel 107.0 ± 9.6; jelly 149.2 ± 16.2. Statistically significant difference was found between Control and Jelly ($p = 0.032$), and Jelly and Honey ($p = 0.002$).

The maximum blood glucose peak was reached at 30' for all tested samples, with the highest peak for Jelly of 8.44 mmol L^{-1}, and the lowest for Honey of 7.35 mmol L^{-1} which was statistically significantly lower in comparison to Control ($p = 0.034$) and Jelly ($p = 0.021$). These results were expected due to glucose/fructose ratio of honey (Hills et al., 2019). Fructose and galactose are metabolized in the liver to glucose and therefore foods that contain higher amounts of these carbohydrates do not cause significant increase in blood glucose (Wolever, 2006), which is the case with honey. However, it should be noted that the GI of honey can vary from low to high due to variable glucose/fructose ratio, and other environmental conditions (such as the season, weather conditions, etc.) (Wolever, 2006; Hills et al., 2019; Atkinson et al., 2021).

Patterson and Gray (2007) examined the impact of carbohydrate gels compared to placebo on performance of football players who were exposed to run training of high-intensity in intervals from walking to running to exhaustion. The results have shown statistically higher values of blood glucose in 15', 30' and 60' of running to exhaustion after consuming Gel versus placebo. Additionally, the period when the exhaustion was achieved during running was statistically longer for Gel then for placebo. These results show that consumption of carbohydrate gels with water improve physical performance probably through maintenance of blood glucose levels during training (Patterson & Gray, 2007). A study which examined effect of gels of low and high GI on appearance of gastrointestinal discomfort (cramps, bloating) in long distance runners, did not find significant problems regardless of the composition of the gel after 16 km running (Pfeiffer, Cotterill, Grathwohl, Stellingwerff, & Jeukendrup, 2009). In addition, it was found that gel carbohydrates oxidize (metabolize) as well as from beverage, which was tested on well-trained cyclists (Pfeiffer, Stellingwerff, Zaltas, & Jeukendrup, 2010). For recovery, especially when time-limited, athletes should prioritize consuming carbohydrate and fluid. Addition of protein has no meaningful effect on athletic performance (McCartney, Desbrow, & Irwin, 2018).

Also, strong negative correlation was found between the change in blood glucose and the subjective satiety score for all test samples (Table 2).

Table 2. Correlation between blood glucose and subjective satiety score for test food.

	Change in blood glucose concentration			
Subjective satiety score	Control	Honey	Gel	Jelly
Control	- 0.63			
Honey		- 0.78		
Gel			- 0.62	
Jelly				- 0.81

Pearson's correlation test, $p < 0.05$.

Accordingly, Honey had the lowest GI (89.6 ± 37.1), followed by the GI of Gel (124.1 ± 61.5) and Jelly (162.1 ± 60.9). Statistically significant difference was found between Honey and Jelly (p = 0.008) (Figure 1).

From the financial side, Honey is more affordable in comparison to tested commercial products: price of Gel is 1.5 EUR 40 g^{-1} pack and the recommended dose is four per day; price for Jelly is 2.0 EUR 50 g^{-1} pack and the recommended dose is 1-2 per day while the price for 900 g of Acacia honey is 11 EUR. In other words, the cost for honey is 80% lower than for Gel and 70% cheaper than for Jelly.

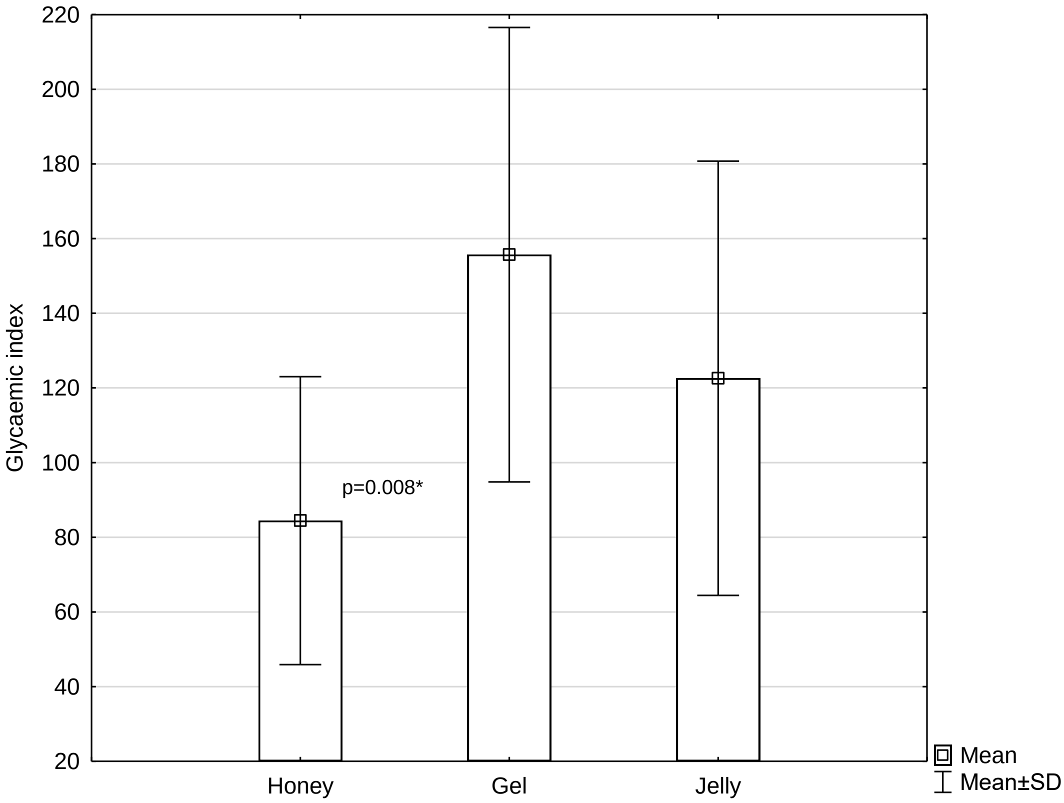

Figure 1. Calculated glycaemic index for test samples.Mean – the mean value; SE –standard error; t-test for independent variables; *indicates statistical significance between Honey and Jelly at p < 0.05.

Ahmad, Ooi, Saat Ismail and Mohamed (2015) conducted a randomized cross-over study on 10 runners in which they tested the impact of Acacia honey drink on a post-exercise recovery and subsequent running performance in the heat. They found that rehydration with Acacia honey drink, in comparison to water increases runners' performance and glucose metabolism (Ahmad et al., 2015). Earnest et al. (2004) examined the effect of low and high GI carbohydrate feedings during a simulated 64-km cycling time trial. Nine cyclists were given 15 g of honey (low GI) after each 16 km, in comparison to dextrose (high GI) and placebo. In the last stage of the trial cyclists accumulated more energy after consuming honey, without differences in heart rate or the intensity of training, i.e. rate of perceived exertion (Earnest et al., 2004).

According to the recommended classification of food according to its GI (ISO, 2010), all tested samples fall into group of high GI and high glycaemic load (GL) foods. Studies in the field of sports indicate that high GI foods and foods with high GL have the most beneficial effect on recovery after a long and intensive exercise, due to improvement in muscle glycogen content (Karas et al., 2015).

As mentioned, GI values are susceptible to large inter- and intra-individual variability (Wolever, 2006, Atkinson et al., 2021), and more effort is needed to improve standardization of formulations to enable better use of available products. This is probably the main reason why the concept of GI is still widely debated and undervalued (Brand-Miller & Buyken, 2020). For example, study by Karas et al. (2015), after analysing two commercially available products for recovery after training (recovery preparations) found that even though both had high GI their mechanism of action is significantly different. Mean GI was 317.9 ± 122.4 for one and 161.6 ± 14.6 for the second product (p = 0.022), and the authors concluded that despite same classification, product formulation is different and has different effect on recovery (Karas et al., 2015). Updating the existing comprehensive database of GI, encouraging industry to standardize their products or be more specific on the mechanism of action could contribute to wider use of GI, which already proved to be important in various health aspects (Blaak et al., 2012).

Study limitations

The study encompassed only male subjects. As previously noted, potentially different GI response can be expected in women and future studies should include women. Type of exercise was not controlled in this study, and it is well documented that it can alter GI. Therefore, studies should consider selecting their study subjects according to the type of exercise, not just the intensity as was done in this case. Finally, testing more products, both commercial sports products and different types of honey would be useful to get a better picture on which products provide the best result per unit price.

Conclusion

The results show that Acacia honey can be considered as a good alternative to sports energy products intended for athletic performance, and a more affordable one. It had the lowest GI, good acceptability, and showed no difference in subjective satiety score from the commercially available products. If compared with other studies that used honey or honey-based products for athletic performance, improved performance, higher glycogen storage and improved recovery are expected.

Acknowledgements

The study was conducted as a part of the Research and implementation project ‘Determination of the glycaemic index of different products’ funded by the Faculty of Food Technology Osijek, Croatia.

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