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DETERMINATION OF THE GLYCAEMIC INDEX OF PREPARATIONS FOR SPORTS PERFORMANCE

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Summary

Introduction: Glycaemic index (GI) of a certain quantity and type of carbohydrate affects the rate of change of glucose concentration or glucose metabolism in blood. Consumption of carbohydrates with different GI before, during and after exercise affects the athletic performance and food with a high GI is preferred.

Aims: To determine GI of two commercially available recovery preparations and accordingly assess their classification in the group of training recovery products.

Methods: Five healthy males, 21 – 26 years, full-time students, non–smokers, volunteered for the study. The main inclusion criteria were absence of diabetes, prediabetes or any other diagnosis that affects glycaemia and intensive physical activity in leisure time, measured through body composition (Tanita MC-180 analyzer) and a standardized physical activity questionnaire. GI determination for two commercially available recovery preparations was done according to ISO 26 642:2010 method.

Results: Test sample 1 had significantly lower hedonic score (4.0 ± 1.7) and a subjective feeling of satiety (50.5 ± 3.6), while Control sample had the highest scores (2.0 or 64.8 ± 9.0). Significantly higher blood glucose was determined for both test samples as compared to Control. The area under the blood glucose curve (iAUC) was significantly higher for Test sample 1 (255.9 ± 50.7) as compared to Control (78.9 ± 8.0), and Test sample 2 (127.3 ± 12.6). GI of Test sample 1 was significantly higher than the one of Test sample 2 (317.9 ± 122.4 versus 161.6 ± 14.6, p = 0.022).

Conclusions: Both samples belong into the category of high GI products, which is in accordance with their intended purpose. The results indicate differences in the mechanism of action; i.e. influence on glucose metabolism, probably as a result of product formulations (nutritional composition). Despite the same classification of two tested products by the manufacturer, more detailed description of mechanism of action for training recovery products should be encouraged.

Key words: controlled clinical study, recovery preparations, glycaemic index, glucose metabolism, sport performance

Introduction

The glycaemic index (GI) is a measure of the food power to raise blood glucose concentration after a meal. The GI is defined as relation of the incremental Area Under the blood glucose response Curve (iAUC) of a tested meal containing 50 g of digestible carbohydrates and the incremental area under the blood glucose response curve of the standard food, i.e. 50 g pure glucose (iAUCS) (Chlup et al., 2004).

It was first introduced thirty years ago (Jenkins et al., 1981) with the aim of identifying the physiological dimension of quality of carbohydrates (CHO) and their divisions. The concept was first developed in response to the critical and specific needs of diabetes management, later evolving towards the general interest. Short-term effects of GI food products, such as postprandial metabolic response, satiety, physical abilities, physiological functions, have been identified in a series of research as important for the long-term outcomes, such as association with the risk for cardiovascular disease, diabetes and obesity. However, GI is still under discussion and guidelines are needed in terms of food processing, dietary recommendations, target population and the public use of the GI concept through health care profession-

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als and experts in the education sector (Wolever, 2006). Research in the early 1980's demonstrated that CHO consumption could improve capacity during prolonged bouts of exercise. Since then, studies have investigated the optimal amount, type and timing of CHO to maximize endurance performance. However, it was not until the early 1990's that GI was first investigated for its potential role in optimizing sport performance.

During a low intensity workout, fats are the main source of energy for sport performance. As the intensity of exercise increases, the need for glucose increases and consequently glycogen muscle storage is being depleted. Therefore, diet rich in CHO correlates with the higher muscle glycogen storage, which improves endurance performance (Wolever, 2006). Although consumption of CHO before, during and after recovery is now generally accepted as a mean of improving endurance performance, the role of high GI and low GI foods in sport nutrition is still being debated (Donaldson et al., 2010).

The GI of a food can be influenced by the physical and chemical characteristics of the food, and although an individual's glycaemic response can be highly variable, most participants' characteristics such as age, sex, body-mass index and ethnicity are not believed to influence GI (Wolever et al., 2003). However, some evidence suggests an interrelation between GI, gender, and training status. Several studies have found a difference between trained and sedentary men (Mettler et al., 2007), whereas others found no difference in the GI using trained and sedentary women (Mettler et al., 2006). If the GI of CHO influences the rate at which CHO elicits blood glucose response, it seems plausible that consuming CHO of differing GI before, during, and after exercise will influence sport performance (Donaldson et al., 2010). Current evidence suggest that for the maximal glycogen synthesis athletes should consume around 1.2 grams of CHO per kg body mass in for of glucose of sucrose right after the training, and every hour afterward through a period of 4 to 6 hours (Spaccarotella and Andzel, 2011). This is of special importance for athletes training 2 times per day, with limited time for recovery (Donaldson et al., 2010). Sports drinks are a better option for a fast glycogen recovery (than solid foods) since they can be taken right after a training or competition when appetite is usually supressed (Spaccarotella and Andzel, 2011).

Energy and sports drinks market is one of the fastest growing, despite numerous health concerns consumers have (Canadean, 2014). Still, economic crisis had a major impact on the market position. For example, in some countries like Croatia, Bosnia and Herzegovina, Hungary, market is in decline, while in Serbia and Czech Republic market of energy and sports drinks shows strong and consistent growth (Euromonitor International, 2014). Consumers have put demands on manufacturers; they need to reignite these products with innovation: new flavours, new no-calorie sweeteners, more natural product ingredients and extracts (Canadean, 2014). More innovation in the category asks for a better labelling and a more detailed categorization of these products (Sports Dietitians Australia, 2011).

Aims

Aims of this controlled clinical study were:

1. to determine the GI of two commercially available powder products, used for the recovery of athletes after training or competition;
2. to determine sensory acceptability of tested products;
3. to determine subjective satiety; and
4. to determine accordance with the manufacturers listed purpose, i.e. recovery, and the expected level of impact in specified area of recovery for these products.

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. Healthy males of minimum 18 years of age, who are actively involved in sports at leisure time (at least 5 days a week), came for an interview to introduce them with the study protocol. Total of 9 subjects volunteered for the study. After informing them about the study, the study consent form was signed.

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). In order to satisfy the strength of the study, minimum of five 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, physical activity questionnaire (Baecke et al., 1982), and anthropometric and body composition was measured by Tanita MC-180 analyzer. After analysing the results on their medical history, physical activity level and anthropometric data, five subjects were selected for the study. They were informed on the precise study protocol for their first study protocol appointment.

Test foods

Three different foods (1–3) with a known carbohydrate composition were tested:

1. Test sample 1 (Twinlab® Ultra Fuel);
2. Test sample 2 (Twinlab® Hydra Fuel);
3. Control (glucose) (Table 1).

The food was prepared professionally in the expected quality and quantity, according to manufacturer's instructions. Foods were prepared freshly, each day. Each serving contained 50 g of digestible carbohydrates. Test samples were dissolved in 300 ml of water, while glucose was dissolved in the same quantity of clear apple juice. Apple juice was selected in order to mimic the colour of other two test foods.

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

	Test sample 1 (serving size 105.3 g)	Test sample 2 (serving size 20 g)	Control (per 100 ml)
Calories	1674 kJ/400 kcal	293 kJ/70 kcal	197 kJ/47 kcal
Total Carbohydrate	100 g	18g	11.7 g
Sugars	34 g	18g	11.5 g
Vitamin C	60 mg	30 mg	1 mg
Thiamin	1.5 mg	0.21 mg	0.02 mg
Riboflavin	1.7 mg	1.7 mg	0.02 mg
Niacin	20 mg	-	0.1 mg
Vitamin B6	2 mg	-	0.03 mg
Biotin	300 µg	-	-
Pantothenic Acid	100 mg	-	-
Magnesium	25 mg	45 mg	7 mg
Chromium	200 µg	18.8 µg	-
Sodium	60 mg	26 mg	3 mg
Potassium	100 mg	-	119 mg

Study design

Glycaemic index (GI) for the two commercially available recovery preparations was done according to ISO 26 642:2010 method (International Standards Organization, 2010). The study protocol was approved by the Ethics Committee for research on humans of the Faculty of Food Technology in Osijek.

Study subjects and test foods were randomized 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 their glucometer (Bayer CONTOUR USB NEXT), lancets and strips (all Bayer). Blood samples were taken at the following time points: -5', 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 assess how much did they liked the food, i.e. to assess their sensory acceptability 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:

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

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 2010 (Microsoft Corp., USA) and Statistica 12.0 (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

Five healthy males, 21 – 26 years, full-time students who live alone and are childless, with an average income of 330 eur/ person, non-smokers, rarely consume alcohol (on a monthly basis) and drink an average of 2 – 2.5 litres of water per day completed the study. Only one subject was taking dietary supplements (protein shakes).

The level of physical activity was assessed through three dimensions, by using Baecke's activity questionnaire. All three dimensions were greater than for the average student population: work index 3.3 (± 0.3), sport index 4.1 (± 0.6) and leisure index 3.9 (± 0.6). Using the same questionnaire, previous study determined work index of 2.3 (± 0.5), sport index 2.9 (± 2.6) and leisure index of 2.9 (± 0.9) for student population (Banjari et al., 2011). In addition, the latest research conducted on student population showed that 25.6% of students are totally inactive while 30.3% of them play sports recreationally, seasonaly (Banjari and Ostrognjaj, 2014).

Anthropometric data and body composition results were in accordance with the reported sport participants were involved in. This especially relates to the muscle mass (66.3 ± 10.1) and whole body impedance (532.8 ± 60.6 Ω), which are in accordance to findings from other studies (Kao et al., 2011; Keogh et al., 2007).

Considering anthropometrics study subjects belong to a category of very active amateurs (Baecke et al., 1982). These findings favour the inclusion criterion; they are considered as potential users of test samples (recovery preparations) since sports they are involved in (i.e. soccer, powerlifting, Olympic weightlifting and bodybuilding) are extremely physically heavy and recovery of muscle glycogen is crucial (American Dietetic Association, 2009; Donaldson et al., 2010; Khanna et al., 2005; Wolever, 2006).

Sensory acceptability

The average consumption time for all test foods was 2.5 to 3.0 minutes, and no side-effects were noted. For the sensory acceptability, statistically significant difference was found between Control and Test sample 1 (2.0 versus 4.0 ± 1.7; p = 0.033) (Fig. 1). Test sample 1 had the lowest preference among subjects. These results can be explained with the different amounts of powder needed to be mixed with water in order to fulfil method requirement of 50 g of available carbohydrates. The highest amount of powder was needed for Test sample 1 (154.9 g, versus 55.6 g of Test sample 2) (Table 1), which resulted in different consistency (thickened consistency). Another important feature for these preparations is their taste (Sports Dietitians Australia, 2011). Due to high amounts of powder needed to prepare test foods taste was very intense which was not considered as appealing for the subjects (Fig. 1). Therefore, we assume that the recognition and familiarity with the taste of clear apple juice which was used as a basis for Control was one of the possible reasons for the best acceptability rating (Fig. 1).

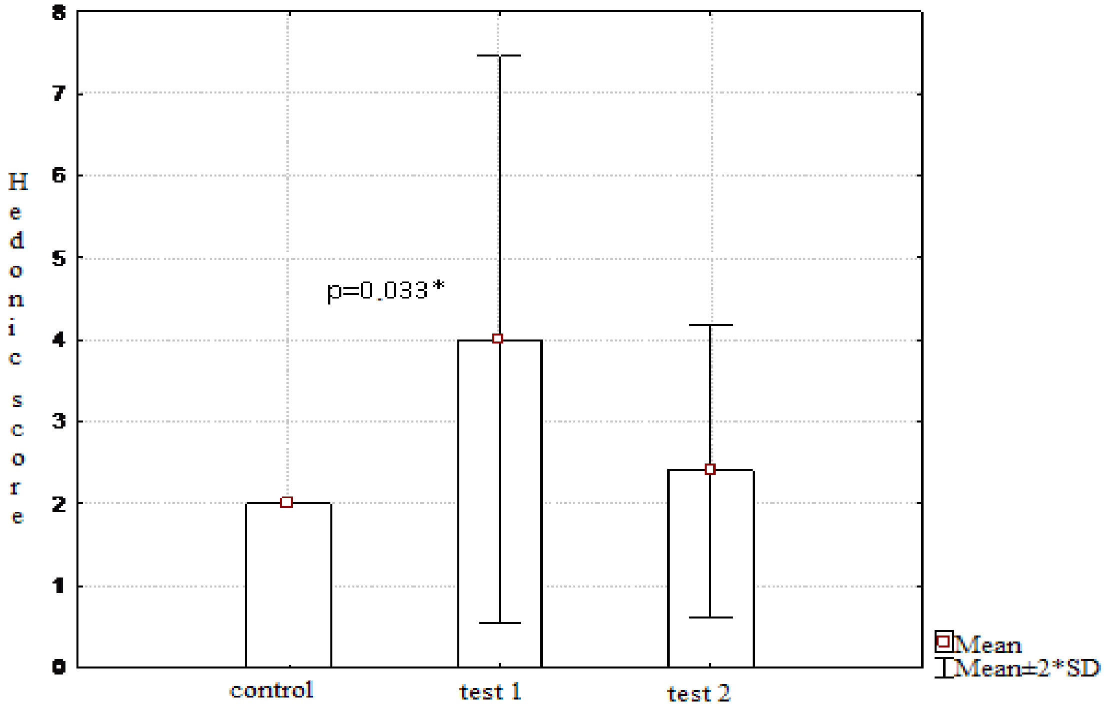

Fig. 1. Sensory acceptability of test foods expressed as hedonic score t-test for independent variables; Mean–the mean value; SD – standard deviation *indicates statistical significance between Control and Test sample1 at p <0.05

Subjective satiety

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 for subjective satiety; solid food causes greater satiety than liquid food or beverage, which is directly related to the physiology and the process of digestion (Banjari et al., 2014; Guyton and Hall, 2003; Wolever, 2006). Statistically significant difference in subjective satiety was found for all three samples tested (Fig.2). Test sample 1 (50.5 ±3.6) and 2 (52.2 ±7.0) have lower subjective satiety as compared to Control (64.8 ±9.0). Moreover, Test sample 1 in 120 minute had significantly lower subjective satiety than Test sample 2 (p =0.016; Fig. 2). These results were unexpected because the change in blood glucose levels (Fig.3) indicated that at 120' blood glucose for Test sample 1 was the highest. However glucose peak was also the highest for Test sample 1, which together with the high content of B complex vitamins higher than the recommended intake observed as DRI (Institute of Medicine, Food & Nutrition Board, 2004); effectors that positively affect appetite (Banjari et al., 2014) in the product (Table 1) can be hypothesized as a possible result for the lowest subjective satiety score. Additional support for the presented hypothesis lies in statistically significant negative correlation (-0.84) found between blood glucose response and subjective satiety score for Test sample 1 (Table 2).

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

	Change in blood glucose concentration		
Subjective satiety score	Control	Test sample 1	Test sample 2
Control	- 0.62		
Test sample 1		- 0.84	
Test sample 2			- 0.69

Pearson's correlation test, $p < 0.05$

Control had the highest subjective satiety score (Fig.2), and when compared to Test sample 1 statistically significant difference was found in 90' (p =0.024), and for Test sample 2 in 15' (p =0.011) and 30' (p=0.032). These results suggest difference in mechanism of action of test samples (content of CHO, combined with high content of B complex vitamins), which emphasizes the need for better labelling, and more detailed categorization of recovery preparations (Jenkins et al., 1981).

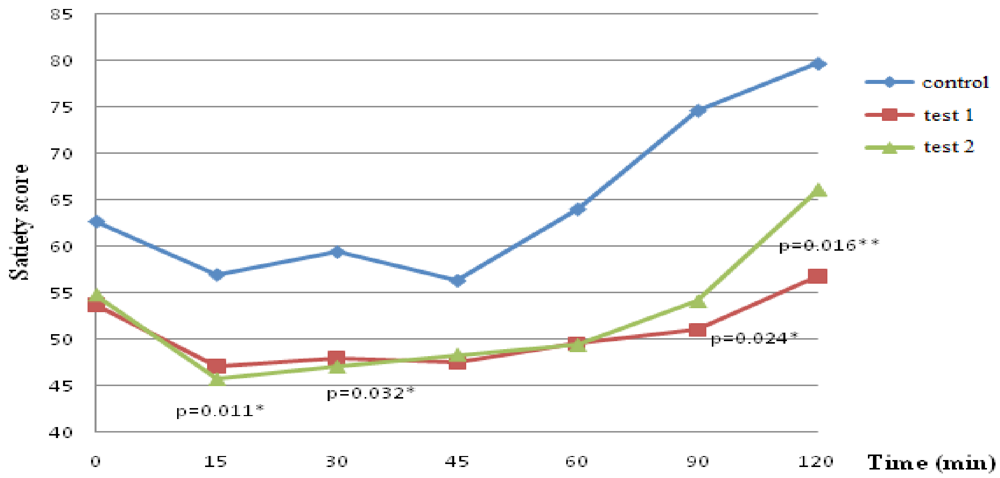

Fig. 2. Subjective satiety curves for three test samples through 120 minutes t-test for independent variables *indicates statistical significance at p <0.05; *compared to Control; **between two Test samples

Blood glucose change

The speed and the intensity of blood glucose levels increase after eating certain meals compared with the standard represents GI. In healthy subjects, a mixed meal affects the normal increase of blood glucose, which causes the secretion of insulin from pancreas in order to normalise levels of glucose back to the basic (basal) level. The amplitude of the increase in blood glucose determines the amount of secreted insulin, and is in direct relation to the number of metabolic disorders, from obesity, diabetes, metabolic syndrome, and others (Wolever, 2006). From the aspect of sports performance, the importance is even greater, especially for high intensity trainings where muscle glycogen recovery is crucial for sports performance (American College of Sports Medicine, 2011; Donaldson et al., 2010; Spaccarotella and Andzel, 2011). By comparing both test samples with Control there was a statistically significantly higher response of blood glucose. Blood glucose concentration was significantly higher from 30' to 120' for Test sample 1 when compared to Control. For Test sample 2 significantly higher concentration as compared to control was found in 45' (p = 0.042). When comparing two test samples, statistically significantly higher blood glucose was found for Test sample 1 in 60' (p = 0.003) and 90' (p = 0.002). Only for Test sample 1 blood glucose did not fall to baseline level (Fig. 3).

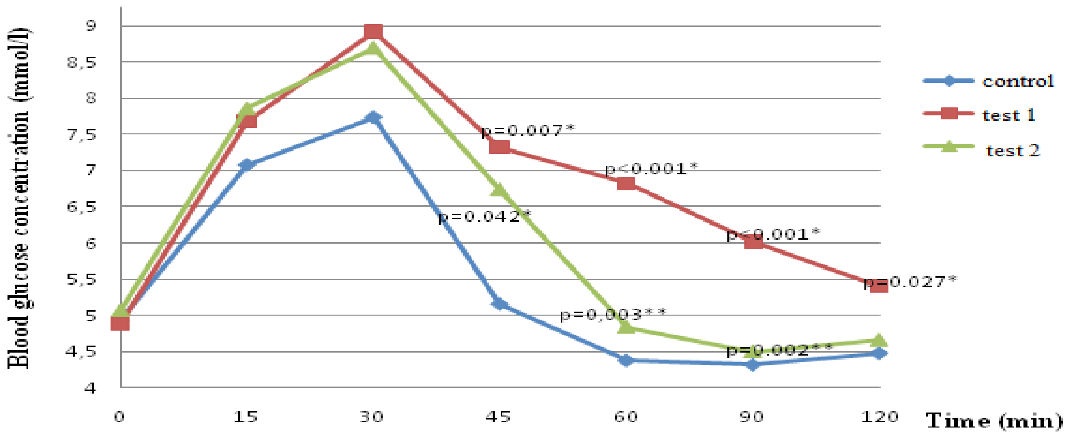

Fig. 3. Change in blood glucose levels of the test samples through 120 minutes
t-test for independent variables
*indicates statistical significance at p <0.05; *compared to Control; **between two Test samples

The results indicate the need for better labelling of such preparations (American College of Sports Medicine, 2011; Sports Dietitians Australia, 2011), since despite being classified in the same category by the manufacturer; clearly the effect on glucose metabolism is significantly different. Compensation for energy after a workout has utmost importance, and should include compensation of glycogen and elimination of accumulated lactate (American College of Sports Medicine, 2011; Donaldson et al., 2010; Guyton and Hall, 2003). Wrong choice of preparations for recovery may have significant adverse effects on exercise capacity and athletic performance, which is again most prominent in top elite sport (American College of Sports Medicine, 2011; Donaldson et al., 2010; Spaccarotella and Andzel, 2011).

Glycaemic index

GI can also be defined as a relationship of incremental or total area under the curve in response to blood glucose of tested food (iAUC, Incremental Area Under the blood glucose Curve tested for the meal) containing 50 grams of free carbohydrates and total area under the curve in response to blood glucose of standard test food (iAUCS, Incremental Area Under the blood glucose Curve for the standard meal) (Chlup et al., 2004).

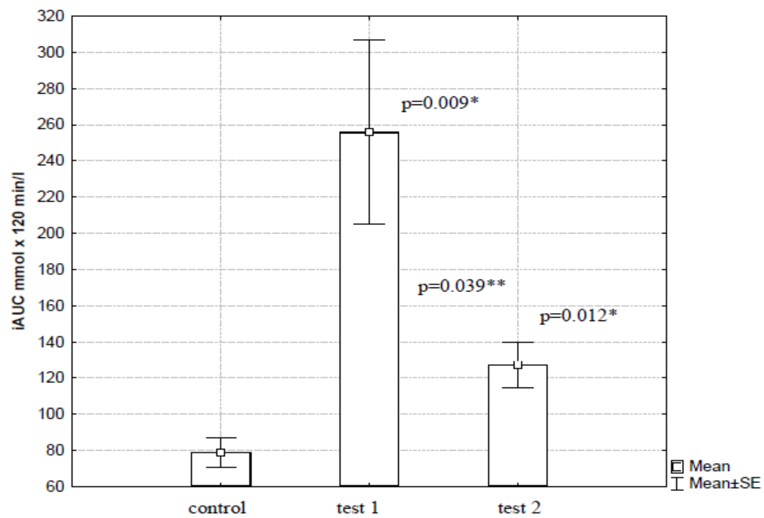

Fig. 4. The area under the blood glucose curve (iAUC) for three test samples
t-test for independent variables; Mean – the mean value; SE –standard error
*indicates statistical significance at p <0.05; *versus control; **between Test samples

Area under the curve was calculated as the sum of the areas of a trapezoid under the glucose concentration curves for the tested samples (Fig. 3) and expressed in 120 mmol x min/l. The calculated iAUC values are as follows: control 78.9±8.0; test sample 1 255.9±50.7; test sample 2 127.3±12.6 (Fig. 4).
Statistically significant difference was found between Control and Test sample 1 (p =0.009) and Test sample 2 (p =0.012). Also, significant difference was determined between Test sample 1 and 2 (p = 0.039; Fig. 4). Meal composition is essential for the normal pancreatic activity; therefore blood glucose level reflects current human need for energy. The amplitude of increase in blood glucose is determined by the amount of secreted insulin. Accordingly, various metabolic disorders lead to disturbance in insulin secretion (Wolever, 2006). It is therefore important to recognize how body reacts on certain foods through their CHO composition and GI. This is especially important for physical fitness, performance and recovery after training, especially for top athletes (American College of Sports Medicine, 2011; Donaldson et al., 2010; Spaccarotella and Andzel, 2011). GI values are susceptible to large inter- and intra-individual variability (Chlup et al., 2004; Foster-Powell et al., 2002; Wolever et al., 2003). In the European Union, the GI of a large number of foods is not determined, and also methods for determining the GI values are not standardized (Wolever et al., 2003). There is a need for standardization and systematic determination of GI of foods in order to keep pace with the advanced fields of manufacturing of novel foods and dietary supplements, as well as scientific evidence on the relationship between GI with numerous health effects (Prašek, 2004; Wolever, 2006). According to GI categories calculated values for both tested samples (Table 3) classify them in the category of high-GI and high glycaemic load (GL).

Table 3. Calculated glycaemic index for test samples

Sample	**Glycaemic index** mean ± SD	**p**
Test 1	317.9 ± 122.4	0.022*
Test 2	161.6 ± 14.6	

SD – standard deviation

t-test for independent samples; * indicates statistical significance at p <0.05

If we consider composition of test samples (Table 1), CHO content and the purpose of tested preparations, high GI was expected. However, GI of Test sample 1 was significantly higher (317.9 ± 122.4 versus 161.6 ± 14.6, p = 0.022; Table 3). These results are consistent with iAUC values (Fig. 4), but they were not expected to be that different, considering their intended purpose. The results indicate that despite the same classification of products in the group of “recovery” preparations by the manufacturer, their effect on glucose metabolism is different.
Study findings are consistent with the results of other studies (Chlup et al., 2004). Likewise, 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 (American College of Sports Medicine, 2011; Sports Dietitians Australia, 2011; Wolever, 2006).

Conclusions

1. According to hedonic score, the highest acceptability had Control, followed by Test sample 2 and the lowest for Test sample 1.
2. Subjective satiety scores was the lowest for Test sample 1 (50.5 ± 3.6), when compared to Control (64.8 ± 9.0) and Test sample 2 (52.2 ± 7.0). Different time points for which the difference was determined (Test sample 1 in 90’, Test sample 2 in 15’ and 30’) suggest difference in mechanism of action due to formulation of these two products (CHO and B complex vitamins).
3. Blood glucose curve of Test sample 1 showed the highest peak and separate glucose con-

centration at time points from 30’ to 120’, which did not fall to baseline level. Consequently, iAUC was the highest for Test sample 1 (255.9 ± 50.7), when compared to Control (78.9 ± 8.0) and Test sample 2 (127.3 ± 12.6).

4. Both test samples belong to a high GI and high GL category, which correlates to the intended purpose, i.e. recovery preparations. Despite same classification, GI of Test sample 1 is statistically significantly higher than the one of Test sample 2 (317.9 ± 122.4 versus 161.6 ± 14.6, p = 0.022).

Determined differences in formulation of the two tested recovery preparations suggest different mechanism of action on glucose metabolism, therefore changing the final outcome intended – recovery of muscle glycogen. This imposes the need for a better labelling, and more detailed classification of recovery products in order to achieve maximum impact on exercise capacity during training and competition as well as sports performance. Adding GI to the existing labels could serve as a starting point for the proposed more detailed labelling. By providing this information only, athletes and their coaches could predict the impact of specific product on muscle glycogen recovery, a crucial aspect in sports performance.

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Conflict of interest statement: None declared.

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ODREĐIVANJE GLIKEMIJSKOG INDEKSA PRIPRAVAKA ZA OPORAVAK NAKON TRENINGA

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Originalni znanstveni rad

Sažetak

Uvod: Glikemijski indeks (GI) određene količine i vrste ugljikohidrata utječe na brzinu promjene koncentracije glukoze u krvi (GUK), odnosno metabolizam glukoze. Konzumacija ugljikohidrata sa različitim GI prije, tijekom i nakon treninga utječe na sportsku izvedbu, a preferira se hrana visokog GI.
Ciljevi: Odrediti GI dva komercijalno dostupna pripravka za oporavak nakon treninga i sljedno tome procijeniti njihovu klasifikaciju u skupini pripravaka za oporavak nakon treninga.
Metode: Pet zdravih studenata, dobi 21 do 26 godina, nepušača se dobrovoljno prijavilo za istraživanje. Glavni kriteriji za uključivanje u istraživanje su bili: izostanak dijagnoze dijabetesa, preddijabetesa ili neke druge koja utječe na glikemiju, te da se ispitanici bave intenzivnom fizičkom aktivnošću u slobodno vrijeme, mjereno preko sastava tijela (Tanita MC-18 analizator sastava tijela) i standardiziranim upitnikom o fizičkoj aktivnosti. Određivanje GI dva komercijalno dostupna pripravka za oporavak nakon treninga je provedeno prema metodi ISO 26 642:2010.
Rezultati: Test uzorak 1 je imao statistički značajno najnižu hedonističku ocjenu ($4{,}0 \pm 1{,}7$) i subjektivni osjećaj sitosti ($50{,}5 \pm 3{,}6$), a Kontrolni uzorak najviše ($2{,}0$ odnosno $64{,}8 \pm 9{,}0$). Statistički značajno višu koncentraciju GUK imala su oba test uzorka u usporedbi sa kontrolom. Površina ispod krivulje (iAUC) je statistički značajno najveća za Test uzorak 1 ($255{,}9 \pm 50{,}7$), u usporedbi s Kontrolom ($78{,}9 \pm 8{,}0$) i Test uzorkom 2 ($127{,}3 \pm 12{,}6$). GI Test uzorka 1 je značajno viši u odnosu na Test uzorak 2 ($317{,}9 \pm 122{,}4$ naprema $161{,}6 \pm 14{,}6$, $p = 0{,}022$).
Zaključci: Oba uzorka spadaju u kategoriju visokog GI, što je u skladu s njihovom namjenom. Dobiveni rezultati upućuju na razlike u mehanizmu djelovanja; tj. na metabolizam glukoze, vjerojatno kao rezultat formulacije proizvoda (nutritivnog sastava). Unatoč istoj klasifikaciji od strane proizvođača, detaljniji mehanizam djelovanja za proizvode namijenjene oporavku nakon treninga bi trebale biti dostupne.

Ključne riječi: kontrolirano kliničko istraživanje, pripravci za oporavak nakon treninga, glikemijski indeks, metabolizam glukoze, sportska izvedba