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Postprandial Glycemic Impact of Diabetes-Friendly High Protein Bars

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ABSTRACT: The rising prevalence of type 2 diabetes mellitus (T2DM) in Malaysia underscores the need for effective dietary strategies to manage postprandial glycemic control. This randomized, open-label, crossover study evaluated the glycemic responses and potential functional benefits of two novel protein bars; ActiSport Acti L2S Fitness Bar and Metabolic Sauver DGI Protein Bar, formulated to support glycemic management and fitness. Fourteen healthy adults consumed each test sample alongside a glucose reference, with blood glucose measured at multiple intervals over 120 minutes. Both protein bars elicited significantly lower incremental area under the curve (iAUC) and glycemic index (GI) values compared to the glucose control, classifying them as low-GI foods (Acti L2S: GI = 14.5 ± 10.0; DGI: GI = 29.7 ± 11.5). The Acti L2S bar's superior glycemic modulation is attributed to lower carbohydrate content, higher dietary fiber, and the inclusion of plant extracts (Garcinia cambogia, white kidney bean, African mango) known for appetite regulation and fat metabolism. The DGI bar provided balanced macronutrients conducive to stable blood glucose and sustained energy release. These findings support the use of both protein bars as functional snacks for postprandial glycemic management, with Acti L2S offering additional slimming benefits. Incorporation of such low-GI, nutrient-dense products may aid individuals with diabetes or metabolic risk in achieving improved glycemic control and metabolic health.

1 INTRODUCTION

Food is a central part of everyone's daily life that's not only shape our nutrition but also our social experiences and personal enjoyment. Malaysia is a country filled with diverse and vibrant food culture, making it a home for many food enthusiasts. However, excessive consumption of refined grains, sugar-sweetened beverages, alcohol and, red processed meat have been linked to the increased risk of developing many diseases, especially type 2 diabetes mellitus (T2DM) (Wu et al., 2014). It is a disease that highly increase the risk of developing various macro- and microvascular complications, which affecting mortality. Diabetes is well known major public health concern in Malaysia (Institute for Public Health (IKU), 2024). Over the past decade, the prevalence of T2DM among Malaysians has increase in an alarming rate. According to Malaysian National Health and Morbidity Survey, T2DM prevalence in Malaysia has increased from 11.2% in 2011 to 18.3% in 2019 and to 15.6% in 2023, which constitute to a 3.6 million of Malaysians (Institute for Public Health (IKU), 2024). When individuals are diagnosed with T2DM, they are strictly required to change their lifestyle to manage their blood glucose and weight. Following the recommended dietary management, they have to learn meal management starting from food selection, preparation, portion control, and even learning to manage responses to possible eating challenges (Yannakoulia, 2006). While main meals can be carefully planned, such as by taking diabetic-formulated meal replacements, snack craving remains as a challenge to suppress. Studies has showed that T2DM patients often choose wrong snacks, especially the sweet and carbohydrate-rich snacks (Heitman et al., 2023; Schmidt et al., 1994). These kinds of snacks can significantly contribute to postprandial glucose spikes and poor long-term glycemic control, which further increase their risk of getting diabetes-complications. Despite the availability of diabetic-formulated meal replacements, there remains a critical gap in glycemia-conscious snack options that are palatable, accessible, and tailored to this community.

Recognizing the need to support healthier snacking habits of diabetes consumer, we developed bars that are aimed to have high amount of protein, healthy fat and fiber, while having low amount of carbohydrate and sugar which are not good for diabetes patients. Protein promotes satiety, slows down carbohydrate digestion and important for muscle maintenance and repair (Halton & Hu, 2004). Healthy fats help to improve lipid profiles by raising HDL good cholesterol and lowering triglycerides, while contributing to sustained energy and improved insulin sensitivity (Riccardi et al., 2004). Fiber promotes gut health, improves satiety, and supports cardiovascular health, all of which are particularly important for people with diabetes who are at higher risk for vascular complications (Anderson et al., 2009). With that, two types of high protein bars; ActiSport Acti L2S Fitness Bar and Metabolic Sauver DGI Protein Bar were created to provide satiety and nutrition while minimizing hunger and glycemic impact. The

DGI protein bar was formulated with variety of healthy nuts and seed with extra cranberry for delightful flavour. Whereas, Acti L2S Fitness Bar was especially formulated for with extra plant extracts; garcinia cambogia, white kidney bean and African mangos to support fitness and slimming. Garcinia cambogia contains hydroxycitric acid (HCA), an active compound known to inhibit citrate lyase, helping to reduce fatty acid synthesis and suppress appetite (Onakpoya et al., 2011). White kidney bean extract functions as an alpha-amylase inhibitor, limiting the digestion and absorption of dietary starches, resulting in lower caloric uptake and enhanced fat reduction (Udani & Singh, 2007). African mango extract has been shown to enhance fat metabolism and regulate appetite through modulation of adiponectin and leptin levels, leading to reductions in body weight, fat mass, and waist circumference (Ngondi et al., 2005). In this study, we aimed to evaluate the glycemic index (GI) of these two bars in comparison to a standard glucose reference. By assessing the postprandial blood glucose response in healthy individuals, we seek to determine the suitability of these bars as low-GI snack alternatives, with potential benefits for glycemic management in the diabetic population.

2 MATERIALS AND METHODOLOGY

2.1 Study Participants

A total of 15 healthy adult volunteers were initially recruited for the study. One participant was excluded from analysis due to non-compliance with test procedures (unable to complete protein bar consumption within the required 15-minute window). Data from the remaining 14 participants (8 males, 6 females) were included in the final analysis. All participants were screened prior to enrolment to ensure normal glycemic status and body composition. Inclusion criteria required a hemoglobin A1c (HbA1c) level below 5.7% and a body mass index (BMI) within the normal range (18.5–24.9 kg/m²).

2.2 Test Foods

Three test samples were used in the study: a glucose reference drink; Glucolin as control, and two experimental protein bars; ActiSport Acti L2S Fitness Bar and Metabolic Sauver DGI Protein Bar, developed as low-glycemic alternatives.

2.2.1 Control Sample

The control was a standard glucose solution prepared by dissolving 53.8 g of Glucolin™ Orange-flavored powder in 250 mL of water, delivering exactly 50 g of available carbohydrates.

2.2.2 Test Protein Bars

The experimental samples were high-protein snack bars prepared to deliver 50 g of available carbohydrates per test. Due to differences in carbohydrate content of the protein bars per serving, participants consumed different quantities of the two bars to match the 50 g carbohydrate target. The ingredients list and the nutritional facts of the two bars are shown in Table 1.

ActiSport Acti L2S Fitness Bar: Each 40 g serving contains 12.3 g of available carbohydrates. Participants were served 163 g (approximately 4 servings) to match 50 g of carbohydrates. The Acti L2S Fitness Bar is formulated with the aim to provide low GI values protein bar that can support fitness and weight loss journey, while improving metabolic health. It is uniquely formulated with three plant extracts; Garcinia cambogia, white kidney bean, and African mango, that have been studied and proven to support slimming and weight loss.

Metabolic Sauver DGI Protein Bar: Per serving of 40 g contains 16.6 g of available carbohydrates. Participants were served 120 g (equivalent to 3 servings) to match 50 g of carbohydrates. This bar is formulated with healthy nuts and seeds that will provide high quality protein and healthy fats.

Table 1. Ingredient Details and Nutritional Facts of the Bars

Parameters	ActiSport Acti L2S Fitness Bar (40 g serving)	Metabolic Sauver DGI Protein Bar (40 g serving)
Ingredients	Sorbitol, soy protein crisps, soluble corn fiber, rolled oat, almond nibs, cocoa powder, sunflower seeds, pumpkin seeds, cashew nuts, isolated soy protein, coconut oil, garcinia cambogia extract, white kidney bean extract, and african mango extract.	Soy protein crisps, soluble corn fiber, oat, dried cranberries, sorbitol, sunflower seeds, pumpkin seeds, cashew nuts, isolated soy protein, coconut oil, and stevia.
Energy (kcal)	171	167
Carbohydrate (g)	12.3	15.4
Total Sugars (g)	1.3	4.7

Dietary Fiber (g)	3.2	2.3
Protein (g)	12.7	12.1
Fat (g)	7.2	5.9
Sodium (mg)	106	76

2.3 Study Design and Procedures

This study employed a randomized, open-label, crossover design. All participants underwent three separate test sessions, each separated by a 2-day washout period to minimize carryover effects.

2.3.1 Blood Glucose Testing

At day 1, after an overnight fast of at least 8 hours (water permitted), participants consumed 250 mL of Glucolin™ drink (50 g carbohydrate) as control test. The consumption must be completed within 15 minutes. Capillary blood glucose was measured via finger prick at time points 0 (baseline), 15-, 30-, 45-, 60-, 90-, and 120-minutes post-consumption.

After a 2-day washout, at day 4, participants consumed 163 g of Acti L2S Fitness Bar (equivalent to 50 g of carbohydrates) within 15 minutes under identical fasting and blood sampling conditions. After another 2-day washout, at day 7, participants consumed 120 g of DGI Protein Bar (equivalent to 50 g of carbohydrates), following the same protocol.

Capillary blood glucose measurements were obtained using the Contour® Plus One glucometer. All finger-prick tests were administered by licensed pharmacists trained in phlebotomy procedures.

2.3.2 Quantification of iAUC and Glycemic index (GI)

Blood glucose data were recorded and used to compute the incremental area under the curve (iAUC) for each test sample using the trapezoidal rule, ignoring values below baseline. From the iAUC of each participant, the glycemic index (GI) of each bar was calculated as a percentage over iAUC of the glucose reference from each participant, following the formula below.

$$GI = \left(\frac{iAUC\ of\ test\ food}{iAUC\ of\ reference\ food}\right) x\ 100$$

2.4 Data Analysis

Statistical comparisons of the iAUC were conducted using 1 Way ANOVA with significance set at $p < 0.001$.

3 RESULT AND DISCUSSION

3.1 Participants Characteristic

A total of 14 healthy participants (8 males and 6 females) completed the study. One participant was excluded from analysis due to inability to consume the test sample within the required 15-minute time frame. The mean HbA1c of the cohort was 5.1%, indicating normoglycemia, and the average BMI was 22.1 kg/m², placing participants within the healthy weight range (Table 2). There was no day-to-day variation on the subjects' usual daily diet intake and physical activity throughout the study period. Every participant attended all the experiment days and the timing of the blood samples taken was strictly followed by the same person in charge that obtained the blood samples. These inclusion criteria ensured the consistency and reliability of the glycemic response measurements across the group.

Table 2. Anthropometric characteristic of study participants (n = 14)

Characteristic	**Mean ± SD**	**Range**
Gender (Male/Female)	Male 8 (57%) Female 6 (43%)	
Age (years)	30.1 ± 5.8	24 - 42
Weight (kg)	61.7 ± 8.3	50.5 – 76.0
Height (m)	1.67 ± 7.9	1.50 – 1.78
BMI (kg/m²)	22.1 ± 2.0	19.6 – 24.4
HbA1C (%)	5.1 ± 0.2	4.6 – 5.5

3.2 Blood Glucose Response

The average capillary blood glucose readings at seven time points (0, 15, 30, 45, 60, 90, and 120 minutes) following ingestion of each test sample are presented in Figure 1 and Table 3. As expected, ingestion of the Glucolin control resulted in a rapid and pronounced spike in blood glucose levels, peaking at 8.9 mmol/L at 45 minutes, before gradually returning to baseline. In contrast, both the Acti L2S Fitness Bar and DGI Protein Bar induced significantly flatter glycemic curves, with much lower peak values and

minimal fluctuation from fasting levels. The Acti L2S Fitness Bar, prompted a minimal rise in glucose, with a peak of only 5.6 mmol/L at 30 minutes, which is only 0.6 mmol/L above baseline before returning to near-fasting levels. The DGI Protein Bar produced a slightly more elevated response, peaking at 6.2 mmol/L, but remained substantially lower than the control. These time-course glucose profiles clearly demonstrate the high glycemic impact of the reference glucose drink and the significantly lower impact of both Acti L2S Fitness Bar and DGI Protein Bar.

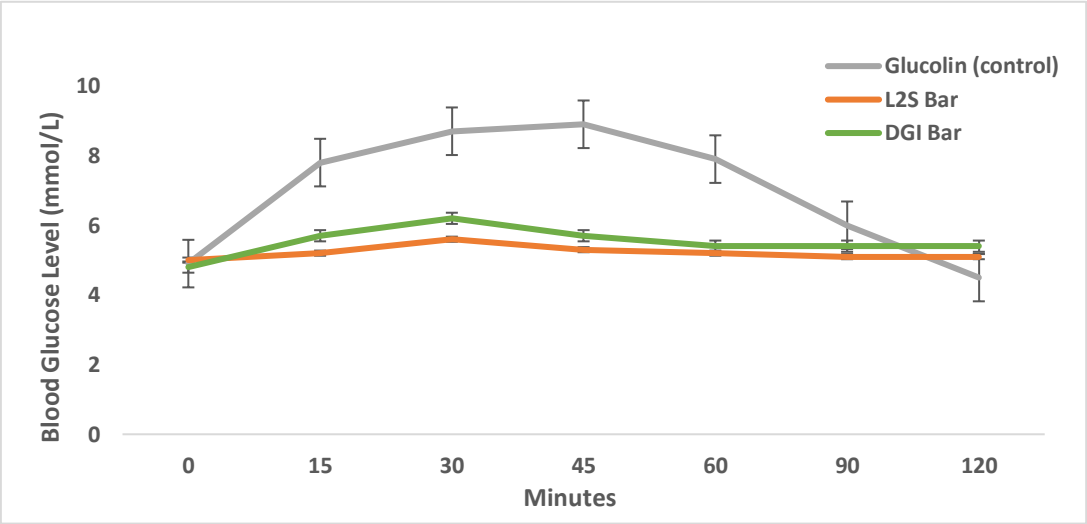

Figure 1. Mean blood glucose (mmol/L) at different time point after consuming respective samples.

The markedly different blood glucose responses observed between the Glucolin control and the protein bars are consistent with the expected physiological effects of rapidly absorbed glucose versus complex nutrient matrices. The Glucolin drink, composed primarily of free glucose, is rapidly absorbed in the small intestine, causing a sharp and high peak in blood glucose levels at 45 minutes (8.9 mmol/L), characteristic of high glycemic index foods (Foster-Powell et al., 2002).

Table 3. Mean blood glucose (mmol/L) at different time points after consuming respective samples.

Samples	Mean blood glucose (mmol/L)						
	0 min	**15 min**	**30 min**	**45 min**	**60 min**	**90 min**	**120 min**
Glucolin Control	4.9 ± 0.4	7.8 ± 1.2	8.7 ± 1.3	8.9 ± 1.3	7.9 ± 1.2	6.0 ± 1.2	4.5 ± 1.1
ActiSport Acti L2S Fitness Bar	5.0 ± 0.4	5.2 ± 0.4	5.6 ± 0.4	5.3 ± 0.6	5.2 ± 0.6	5.1 ± 0.4	5.1 ± 0.4
Metabolic Sauver DGI Protein Bar	4.8 ± 0.5	5.7 ± 0.6	6.2 ± 0.6	5.7 ± 0.8	5.4 ± 0.6	5.4 ± 0.5	5.4 ± 0.3

In contrast, the Acti L2S Fitness Bar and DGI Protein Bar elicited significantly lower blood glucose values relative to the glucose control (5.6 mmol/L and 6.2 mmol/L, respectively). This might be attributed to their low carbohydrate (12.3 g and 15.4 g, respectively) and total sugars values (1.3 g and 4.7 g, respectively). The result might also be due to the high protein (12.7 g and 12.1 g, respectively), fat (7.2 g and 5.9 g, respectively) and dietary fiber values (3.2 g and 2.3 g, respectively). Protein and fat have been reported to able to delay gastric emptying and stimulate insulin secretion (Lan-Pidhainy & Wolever, 2010), while dietary fiber, especially soluble fiber from rolled oats and soluble corn fiber help to slow gastric emptying and carbohydrate absorption (Jenkins & Jenkins, 1985; Slavin, 2013). Thereby, blunting postprandial glucose excursions and maintaining glucose homeostasis in the subjects. Additionally, the lower blood glucose result in the Acti L2S Fitness Bar is believed to be further supported by the white kidney bean extract which can act as an alpha-amylase inhibitor. It limits the digestion and absorption of dietary starches, which results in decreased caloric uptake and supports fat reduction (Udani & Singh, 2007).

3.3 The incremental area under the curve (iAUC) and Glycemic Index (GI)

To quantify the glycemic responses observed, the incremental area under the curve (iAUC) was calculated for each participant following ingestion of the Glucolin glucose reference, Acti L2S Fitness Bar, and DGI Protein Bar. Table 4 presents individual participant data, including maximum blood glucose values (G_{Max}), times to peak blood glucose ($T_{Highest}$), and calculated iAUCs.

Table 4. Each individual's reading of the maximum blood glucose value (G_{Max}), the highest blood glucose time ($T_{Highest}$) and the area under curve (iAUC) after consuming the samples.

Subject	Maximum Glucose (G_{Max}) (mmol/L)			Highest Glucose Time ($T_{Highest}$) (Minutes)			iAUC		
	Glucolin	Acti L2S Bar	DGI Bar	Glucolin	Acti L2S Bar	DGI Bar	Glucolin	Acti L2S Bar	DGI Bar
1	8.2	5.6	6.2	30	30	30	199.5	36.8	46.5
2	6.7	4.7	5.2	60	15	30	138.8	36.0	23.3
3	9.4	5.6	5.6	30	30	30	300.0	13.5	106.5
4	9.0	5.3	5.9	45	30	30	330.8	31.5	180.0
5	10.7	5.9	6.8	45	30	30	399.0	51.8	92.3
6	9.5	5.6	6.7	30	30	15	324.8	52.5	103.5
7	10.0	5.4	6.5	45	30	30	292.5	1.5	69.8
8	9.8	6.2	6.7	30	45	45	228.8	71.3	81.0
9	9.2	5.7	5.7	30	30	15	346.5	63.8	130.5
10	9.5	6.4	6.1	30	30	30	231.0	46.5	57.8
11	8.6	5.8	5.9	60	30	15	258	14.3	19.5
12	8.8	5.1	5.7	45	30	30	191.3	15.0	75.8
13	9.0	5.9	6.5	30	45	30	266.3	6.8	67.5
14	11.7	6.1	7.5	45	15	30	387.8	115.5	142.5

The mean iAUC values illustrated in Figure 2 demonstrate a clear statistically significant ($p \leq 0.001$) distinction between the glucose control and the two protein bars. The Glucolin control elicited the highest glycemic response with a mean iAUC of 278.2 mmol·min/L, whereas the Acti L2S Fitness Bar elicited a substantially lower mean iAUC of 39.8 mmol·min/L. The DGI Protein Bar induced an intermediate response, with a mean iAUC of 85.4

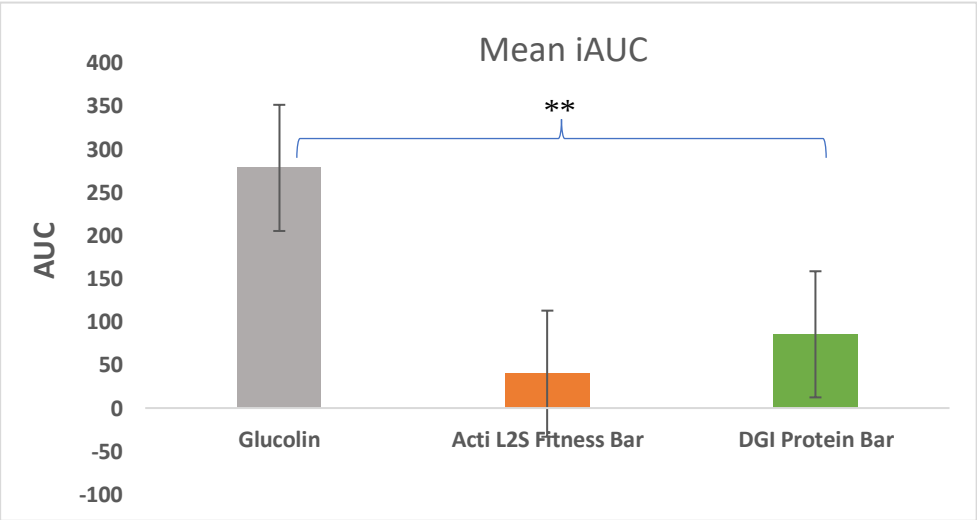

Figure 2. Mean iAUC of subjects after consuming the tested food; Glucolin Control, ActiSport Acti L2S Fitness Bar and Metabolic Sauver DGI Protein Bar (n = 14).

Correspondingly, the glycemic index (GI) values calculated relative to Glucolin (Table 5) were 14.5 ± 10.0 for the Acti L2S Fitness Bar and 29.7 ± 11.5 for DGI Protein Bar. Both values fall well below the ISO 26642:2010 threshold of 55, which classifies foods as low glycemic index. These findings confirm that both protein bars have a low glycemic impact compared to the reference glucose drink.

Table 5. Glycemic Index (GI) of the tested food samples.

Food Samples	Mean GI Value	GI Category
ActiSport Acti L2S Fitness Bar	14.5 ± 10.0	Low (< 55)
Metabolic Sauver DGI Protein Bar	29.7 ± 11.5	Low (< 55)

The difference in glycemic responses between the two bars likely reflects their distinct formulations. The Acti L2S Fitness Bar's lower carbohydrate and sugar contents, higher dietary fiber, and inclusion of botanical extracts that inhibit carbohydrate digestion contribute to its superior glycemic profile. The DGI Protein Bar, although less potent in this regard, still provides a nutrition profile conducive to stable blood glucose management. Low-GI foods are beneficial for improving postprandial glycemic control and reducing glycemic variability. This is particularly important for individuals with diabetes or insulin resistance, for whom managing blood glucose excursions is critical to preventing long-term complications (Elsayed et al., 2023). In practical terms, incorporating either the Acti L2S Fitness Bar or DGI Protein Bar into the diet can help individuals maintain stable postprandial glucose levels, support sustained energy release, and reduce the risk of glycemic spikes. These functional foods therefore represent valuable options for consumers aiming to optimize glycemic control and metabolic health.

4 CONCLUSION

This study demonstrates that both Acti L2S Fitness Bar and DGI Protein Bar elicit significantly lower postprandial glycemic responses compared to a standard glucose reference drink in healthy individuals. The markedly reduced incremental area under the curve (iAUC) and low glycemic index (GI) values for both bars confirm their classification as low-GI foods according to ISO 26642:2010 standards. These characteristics make them suitable snack options for individuals aiming to manage postprandial blood glucose, including those with diabetes or insulin resistance.

The superior glycemic profile of the Acti L2S Fitness Bar can be attributed to its lower carbohydrate and sugar contents, higher dietary fiber, and inclusion of functional botanical extracts such as Garcinia cambogia, white kidney bean, and African mango, which collectively contribute to enhanced carbohydrate digestion inhibition, appetite regulation, and fat metabolism. Conversely, the DGI Protein Bar, while lacking these botanical extracts, still maintains a favorable nutrition composition that supports stable glycemic control and sustained energy release.

The findings underscore the importance of formulating snacks that not only provide essential macronutrients but also incorporate functional ingredients to modulate glycemic impact and support weight management. Incorporating such protein bars into daily dietary regimens can assist in minimizing glycemic excursions, promoting metabolic health, and potentially reducing the risk of diabetes-related complications.

Future investigations exploring long-term effects on insulin sensitivity, weight management, and cardiometabolic markers will further elucidate the clinical benefits of these functional protein bars within diverse populations. Overall, ActiSport Acti L2S Fitness Bar and Metabolic Sauver DGI Protein Bar represent promising dietary strategies for improving glycemic control and supporting healthy lifestyle interventions in at-risk individuals.

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