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MODULATING THE GLYCEMIC INDEX AND GLYCEMIC LOAD OF JAME-E-SHIRIN THROUGH ISPAGHULA HUSK INTERVENTION

Original Research

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ABSTRACT

Background: Excessive intake of sugar-sweetened beverages (SSBs) significantly contributes to the global rise in diabetes mellitus and related cardiometabolic disorders. Pakistan ranks third worldwide in diabetes prevalence, with contributing factors including genetics, sedentary behavior, obesity, and unhealthy diets. The glycemic index (GI) and glycemic load (GL) are essential parameters for managing hyperglycemia, reflecting the quality and quantity of carbohydrates consumed. Increasing dietary fiber intake is known to reduce glycemic response; however, data on GI and GL values of commonly consumed Pakistani beverages remain limited.

Objective: This study aimed to determine the glycemic index and glycemic load of *Jam-e-Shirin* and to evaluate the effect of ispaghula husk (Psyllium Husk) on its postprandial glycemic response.

Methods: A non-blind interventional study was conducted over six months at Khyber Medical University, enrolling 15 healthy male participants aged 22 ± 0.83 years with normal BMI and blood pressure. Participants ingested 25 g of reference glucose and 33 mL of *Jam-e-Shirin* containing equivalent carbohydrates, followed by *Jam-e-Shirin* fortified with 2.5 g, 5 g, and 10 g of ispaghula husk. Blood glucose levels were measured at 0, 15, 30, 60, 90, and 120 minutes. The incremental area under the curve (iAUC) was calculated using the trapezoid method to derive GI and GL, and statistical analysis was performed using a Paired T-Test in SPSS ($p < 0.05$).

Results: The reference glucose exhibited a GI of 100 and GL of 25. *Jam-e-Shirin* alone showed a GI of 82.77 and GL of 20.69, which were significantly reduced after adding dietary fiber. GI and GL decreased to 42.63 and 10.64 with 2.5 g fiber, 49.49 and 12.36 with 5 g fiber, and 46.42 and 11.60 with 10 g fiber, demonstrating p-values of 0.01, 0.02, and 0.01, respectively. The 5 g fiber dose produced the most balanced reduction in glycemic response.

Conclusion: The addition of ispaghula husk to *Jam-e-Shirin* markedly reduced its glycemic index and glycemic load, highlighting a practical dietary approach for managing postprandial glycemia and reducing diabetes risk among frequent consumers of sweetened beverages.

Keywords: Blood glucose, Dietary fiber, Glycemic index, Glycemic load, Ispaghula husk, Postprandial glycemia, Sugar-sweetened beverages.

INTRODUCTION

Diabetes mellitus is a chronic metabolic disorder characterized by persistently elevated blood glucose levels resulting from impaired insulin secretion, action, or both (1). It manifests primarily in two forms: Type 1 Diabetes, marked by deficient insulin production due to autoimmune destruction of pancreatic β-cells, and Type 2 Diabetes, in which peripheral tissues fail to respond adequately to insulin (2). Among the major dietary contributors, excessive intake of sugar-sweetened beverages (SSBs)—including soft drinks, fruit juices, sports drinks, and locally consumed sweetened beverages—has been shown to increase the risk of diabetes while exerting adverse effects on the cardiometabolic system (3). Globally, diabetes remains one of the foremost causes of morbidity and mortality, with its prevalence rising alarmingly over recent decades (4). The International Diabetes Federation (IDF) reported that the global diabetic population increased from 285 million in 2009 to 425 million in 2017, and further to 463 million in 2019, with projections suggesting 642 million cases by 2040. Notably, the prevalence in urban regions (10.8%) surpasses that of rural areas (7.2%) (5,6). In Pakistan, diabetes mellitus represents an escalating public health challenge. The national prevalence of Type 2 Diabetes Mellitus (T2DM) is estimated at 11%, with a slightly higher rate among men (11.2%) compared to women (9.19%) (7). By 2021, Pakistan ranked third globally in diabetes burden, following China and India, with 33 million adults affected and approximately 400,000 deaths attributed to the disease (8). This surge is attributed to a complex interplay of genetic predisposition, environmental exposures, sedentary lifestyles, obesity, and the widespread consumption of unhealthy, high-calorie foods. Given this context, understanding modifiable dietary factors that may mitigate diabetes risk is of great importance. Among these, limiting SSB intake has been identified as a significant strategy to reduce obesity and T2DM prevalence (9). Research indicates that diets producing lower postprandial glycemic responses are associated with reduced risk of metabolic syndrome, T2DM, and cardiovascular diseases compared with high-glycemic diets (10,11). Yet, many individuals remain unaware of the complications linked to poor glycemic control (12).

The concept of the glycemic index (GI), introduced by Jenkins and colleagues, measures how rapidly carbohydrate-containing foods raise blood glucose compared with a standard reference such as glucose or white bread (13,14). The GI is defined as the incremental area under the two-hour blood glucose curve (iAUC) after ingestion of 50 g of available carbohydrate, expressed as a percentage of the response produced by the reference food (1,15). Foods are categorized as low (GI < 55), medium (GI 56–69), or high (GI ≥ 70) based on their impact on postprandial glucose levels (14). High-GI foods, such as refined bread, cause rapid glucose absorption and exaggerated insulin responses, while low-GI foods result in slower digestion and more stable glycemic control (16). Despite the global utility of GI as a dietary tool, information regarding the GI of traditional Pakistani foods and beverages remains scarce (2,10). To complement GI, the concept of glycemic load (GL) was developed to account for both carbohydrate quality and quantity. It is calculated by multiplying the GI of a food by the carbohydrate content per serving and dividing by 100 (11). GL values categorize foods as low (<10), medium (11–19), or high (>20). Diets with lower GL have been associated with improved glycemic control in individuals with diabetes or prediabetes. Reducing GL can be achieved by increasing dietary fiber intake and decreasing the consumption of high-GI foods such as white bread (11,12). Dietary fiber—defined by the Codex Alimentarius Commission as non-digestible carbohydrate polymers resistant to enzymatic breakdown in the small intestine (12)—is a particularly valuable dietary component. Soluble fibers, such as psyllium (ispaghula husk), form viscous gels in the intestine, delaying glucose and lipid absorption and consequently lowering both GI and GL (13). A high-fiber, low-GI, and low-GL diet is further linked with reduced inflammation and chronic disease risk, including diabetes and certain cancers (14). Despite growing evidence supporting the benefits of low-GI diets, limited data exist on the glycemic properties of locally available beverages in Pakistan. Given the popularity of Jam-e-Shirin—a traditional sweetened herbal drink—there is a need to assess its glycemic characteristics. Moreover, understanding whether supplementation with soluble fiber such as ispaghula husk can attenuate its glycemic impact may provide valuable dietary guidance for diabetes management. This study aims to determine the glycemic index (GI) and glycemic load (GL) of Jam-e-Shirin and to evaluate the effect of ispaghula husk (psyllium fiber) on modulating its postprandial glycemic response among healthy individuals.

METHODS

This non-blind interventional study with repeated measures was conducted over a period of six months at the Laboratory of the Institute of Paramedical Sciences, Khyber Medical University, Peshawar. A total of 15 healthy male volunteers were recruited from the same

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institution. The participants had a mean age of 22 ± 0.83 years. Eligibility was determined based on specific inclusion and exclusion criteria designed to ensure homogeneity of the study sample. The inclusion criteria comprised individuals with a Body Mass Index (BMI) between 18.5–24.5 kg/m², fasting blood glucose levels ranging from 75–100 mg/dL, non-smokers, and those free from any known genetic or metabolic disorders. Individuals who were obese, smokers, or alcohol consumers, or those with a family history of diabetes mellitus, were excluded from participation. Similarly, participants taking any medications known to influence postprandial glucose levels were excluded to minimize confounding factors. Prior to participation, all individuals were provided with a comprehensive explanation of the study's purpose, procedures, and potential risks. Written informed consent was obtained from each participant. Ethical approval was granted by the Ethical Committee of Khyber Medical University, ensuring adherence to institutional and international ethical research standards. The study protocol was implemented across three distinct experimental sessions, each separated by a washout period of at least 24 hours to avoid carry-over effects. Participants were instructed to abstain from strenuous physical activity and maintain a consistent diet on the day preceding each test. After an overnight fast of 10–12 hours, fasting venous blood samples were collected on the morning of each test using sodium fluoride (gray-top) tubes for glucose estimation.

On the first test day, each participant ingested a reference solution containing 25 g of anhydrous glucose (Glaxose-D) dissolved in 300 mL of water. Participants remained seated and refrained from any physical activity during the 2-hour postprandial period. Blood samples were obtained at 15-minute intervals up to 120 minutes following ingestion. Plasma glucose concentrations were determined spectrophotometrically using the glucose oxidase-peroxidase (GOD-POD) method, which provides reliable quantitative assessment of blood glucose.

On the second day, the same protocol was repeated; however, participants were administered 33 mL of Jam-e-Shirin—a commonly consumed local beverage—diluted in 300 mL of water, providing an equivalent carbohydrate content of approximately 25 g of glucose. Blood glucose levels were measured at 15-minute intervals for 120 minutes post-ingestion. On the third experimental day, participants were divided into three subgroups (n = 5 per group) to assess the effect of ispaghula husk (psyllium fiber) on glycemic response. Each group received Jam-e-Shirin (33 mL) mixed with varying doses of ispaghula husk—2.5 g for Group 1, 5 g for Group 2, and 10 g for Group 3—dissolved in 300 mL of water. Fasting glucose levels were determined before beverage administration, and subsequent postprandial glucose readings were collected every 15 minutes over a 2-hour period under controlled laboratory conditions. Following data collection, glucose response curves were plotted for the reference glucose solution, Jam-e-Shirin alone, and Jam-e-Shirin with fiber supplementation. The incremental area under the curve (iAUC) for each test meal was computed using the trapezoidal rule in Microsoft Excel. The glycemic index (GI) of each test food was calculated as the ratio of its iAUC to that of the reference glucose solution, multiplied by 100. The glycemic load (GL) was then derived by multiplying the GI by the carbohydrate content of the serving and dividing by 100. Data were analyzed using the Statistical Package for the Social Sciences (SPSS) software. The Paired t-test was employed to compare mean postprandial glucose responses among the different test conditions, with a significance level set at $p < 0.05$. Descriptive statistics were used to express continuous variables as mean ± standard deviation

RESULTS

A total of fifteen healthy male participants with normal body mass index and blood pressure successfully completed the study. On the first experimental day, the mean fasting blood glucose level of all participants was recorded at 95 mg/dL. Following the ingestion of 25 g of reference glucose, blood glucose concentrations increased to 129, 149, 112, 96, and 89 mg/dL at 15, 30, 60, 90, and 120 minutes, respectively. The incremental area under the curve (iAUC), calculated using the trapezoidal method, was 2251 mg/dL*sec, corresponding to a glycemic index (GI) of 100 and a glycemic load (GL) of 25. On the second day, after consuming 33 mL of Jam-e-Shirin, the mean fasting blood glucose remained 95 mg/dL, with subsequent readings of 137, 140, 101, 92, and 90 mg/dL at 15, 30, 60, 90, and 120 minutes, respectively. The iAUC for Jam-e-Shirin was calculated as 1863.23 mg/dL*sec, with corresponding GI and GL values of 82.77 and 20.69, respectively. Peak glucose levels were observed at 30 minutes, followed by a steady decline below baseline by 90 and 120 minutes. When ispaghula husk (dietary fiber) was introduced, all three intervention groups demonstrated a reduction in postprandial glucose response. In the group receiving 2.5 g of fiber, blood glucose levels were 91, 113, 116, 89, 83, and 86 mg/dL at the designated time intervals, resulting in an iAUC of 959.9 mg/dL*sec, a GI of 42.63, and a GL of 10.64. In the group administered 5.0 g of fiber, the glucose levels were 96, 118, 125, 98, 90, and 84 mg/dL, with an iAUC of 1114.38 mg/dL*sec, a GI of 49.49, and a GL of 12.36. The group supplemented with 10 g of fiber exhibited glucose readings of 94, 109, 117, 104, 94, and 91 mg/dL, producing an iAUC of 1045.48 mg/dL*sec, a GI of 46.42, and a GL of 11.60. Statistical analysis using the paired t-test revealed that all three fiber doses significantly reduced both GI and GL compared with Jam-e-Shirin alone ($p < 0.05$). The two-tailed significance levels for GI were

0.01, 0.02, and 0.01 for 2.5 g, 5.0 g, and 10 g of fiber, respectively. Similarly, GL reductions demonstrated p-values of 0.01, 0.02, and 0.01 for the same respective doses. Although all fiber concentrations reduced postprandial glycemia, the 5.0 g fiber supplementation produced the most optimal reduction in both GI and GL, as indicated by the mean difference analysis.

Table 1: iAUC, GI, and GL of reference glucose and jam e Shirin without fiber.

Reference glucose		
S.no	Variable	Results
1	iAUC	2251mg/dl*sec
2	GI	100
3	GL	25g
Jam e Shirin without fiber		
S.no	Variable	Results
1	iAUC	1863.23mg/dl*sec
2	GI	82.77
3	GL	20.69g

Table 2: iAUC, GI, GL of different gram of fiber with jam e Shirin

Jam e Shirin with 2.5 gram of fibers		
S.no	Variable	Results
1	iAUC	959.9mg/dl*sec
2	GI	42.63
3	GL	10.64g
Jam e Shirin with 5 grams of fiber		
S.no	Variable	Results
1	iAUC	1114.38mg/dl*sec
2	GI	49.49
3	GL	12.36g
Jam e Shirin with 10 grams of fiber		
S.no	Variable	Results
1	iAUC	1045.48mg/dl*sec
2	GI	46.42
3	GL	11.60g

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Table 3: Pre and Post Fiber Glycemic Index and Glycemic Load of Different Gram of Fiber.

S.no	Different gram of fiber	Pre fiber		Post fiber		Results	
		mean(g)	SD	mean(g)	SD	T value	Sig(2-tailed)
Pre and post fiber glycemic index							
1	2.5 grams	77.09	±18.1	42.63	±16.91	4.19	0.01
2	5.0 grams	88.84	±19.1	49.49	±15.18	3.66	0.02
3	10 grams	82.27	±18.6	46.42	±12.44	8.50	0.01
Pre and post fiber glycemic load							
1	2.5grams	19.27	±4.53	10.64	±4.23	4.19	0.01
2	5.0 grams	22.20	±4.78	12.36	±3.79	3.67	0.02
3	10 grams	20.56	±4.65	11.60	±3.12	8.54	0.01

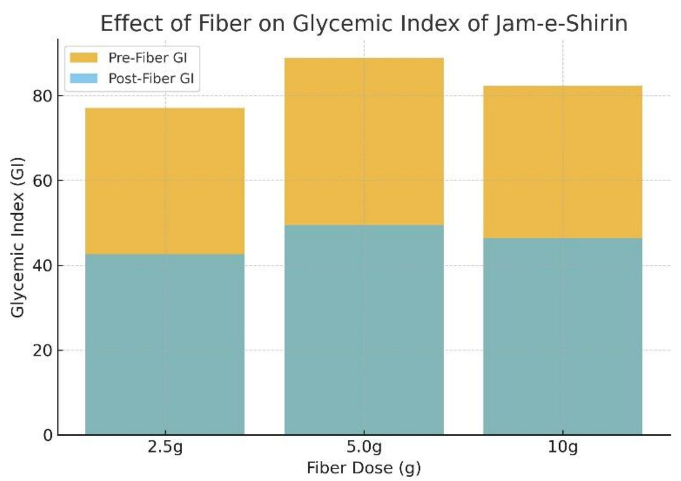

Figure 2 Effect of Fiber on Glycemic Index of Jam-e-Shirin

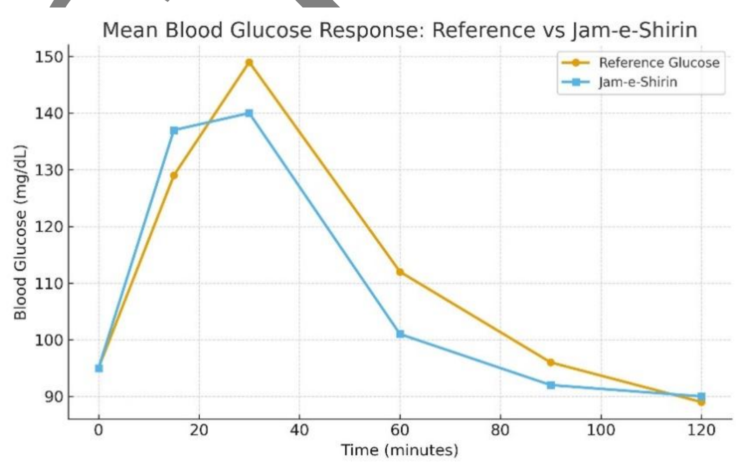

Figure 2 Mean Blood Glucose Response: Reference vs Jam-e-Shirin

DISCUSSION

The glycemic index (GI) and glycemic load (GL) of foods are central in the dietary management of hyperglycemia and in the prevention of metabolic complications associated with diabetes mellitus. These indices serve as valuable tools in guiding dietary choices for individuals with diabetes or those at elevated risk of developing glucose intolerance. Within the Pakistani context, limited data exist regarding the GI and GL values of locally consumed beverages, despite their substantial contribution to overall carbohydrate intake. The present study addressed this gap by evaluating the effect of dietary fiber supplementation on the GI and GL of *Jam-e-Shirin*, a sweetened herbal beverage that constitutes nearly 60% of beverage consumption in Pakistan. The findings of this study demonstrated that *Jam-e-Shirin* alone exhibited a moderately high GI (82.77) and GL (20.69), categorizing it as a food that may provoke significant postprandial hyperglycemia. However, the incorporation of dietary fiber (ispaghula husk) at doses of 2.5 g, 5 g, and 10 g markedly attenuated the glycemic response. The respective GI and GL values were reduced to 42.63 and 10.64, 49.49 and 12.36, and 46.42 and 11.6 (15-17). Among these, the 5 g fiber concentration demonstrated the most balanced and sustained reduction in postprandial glycemia. This hypoglycemic effect is attributed to the viscous nature of soluble fiber, which delays gastric emptying, slows glucose absorption, and enhances insulin sensitivity, thereby reducing the overall glycemic response. The results of this study align with existing literature showing that fiber-enriched diets significantly mitigate glycemic excursions. Similar findings were reported in previous experimental studies where the addition of dietary fiber to glucose or carbohydrate-based foods led to a pronounced decline in postprandial blood glucose concentrations at 30, 60, and 120 minutes (18,19). These observations reinforce the physiological role of soluble fiber in modulating glucose metabolism by forming gel-like matrices in the intestine that impede carbohydrate hydrolysis and absorption.

Comparative evidence from other populations further substantiates the present results. In a study conducted to evaluate the GI and GL of staple Ethiopian foods such as *Teff Injera*, *White Wheat Bread*, and *Corn Injera*, the GI values were reported as 36, 46, and 97, respectively, indicating that foods with lower fiber content and higher processing levels tend to produce greater glycemic responses (20). Similarly, an investigation assessing the GI and GL of vegetable-based drinks, including cucumber, carrot, and beetroot juices, identified mean GI and GL values of 34 ± 10 and 4.4, respectively, which were classified as low glycemic foods (21). These findings parallel the present study in demonstrating that natural or fiber-rich beverages exhibit a lower glycemic potential than refined or sugar-laden ones. The reduction observed with *Jam-e-Shirin* fortified with ispaghula husk supports the broader concept that soluble dietary fiber can convert a high-GI beverage into a lower-GI alternative, thereby contributing to better glycemic control and cardiovascular protection. The implications of these findings extend beyond individual dietary recommendations to the broader public health context. Regular consumption of sweetened beverages has been strongly associated with the increasing prevalence of obesity, insulin resistance, and Type 2 Diabetes Mellitus. The study suggests that fortifying such beverages with soluble fiber could offer a pragmatic nutritional strategy to mitigate their glycemic burden without necessitating complete avoidance. Moreover, this intervention approach may enhance consumer compliance in populations where such drinks are culturally embedded in daily diets.

Despite its contributions, the present study acknowledges several limitations. The sample size of fifteen participants, divided into subgroups of five, restricts the statistical power and generalizability of the results. A larger cohort would have enabled a more robust evaluation of inter-individual variability in glycemic response. Additionally, the study utilized *Jam-e-Shirin* as the sole test beverage; thus, the findings cannot be extrapolated to other locally consumed drinks with differing carbohydrate compositions. Furthermore, the equivalence of 33 mL of *Jam-e-Shirin* to 25 g of glucose, although standardized for testing, was not chemically validated, potentially introducing a margin of error in GI calculation. The absence of female participants also limits the representativeness of the sample, given potential sex-based differences in glucose metabolism. Nevertheless, the study's strengths lie in its controlled experimental design, standardized sampling intervals, and consistent methodology for iAUC and GI/GL estimation using the trapezoidal method. The reproducibility of the results and the clear dose–response relationship between fiber quantity and glycemic reduction underscore the internal validity of the findings. Future research should aim to expand this work by incorporating a larger and more diverse population, including both genders and varying age groups. Additionally, assessing a broader range of local foods, such as fast foods, carbonated drinks, and staple carbohydrate sources like rice and fried snacks, would provide a more comprehensive understanding of the glycemic characteristics of the Pakistani diet (22). Investigating the effects of mixed-meal compositions and the interaction between different fiber types may further refine dietary recommendations for glycemic management in diabetic and pre-diabetic populations. In summary, the study provides evidence that the addition of dietary fiber significantly lowers the GI and GL of *Jam-e-Shirin*, suggesting a potential dietary modification strategy to reduce the glycemic impact of commonly consumed sweetened beverages in Pakistan. These findings emphasize the importance of incorporating fiber-rich options into daily dietary habits as a preventive measure against hyperglycemia and its associated complications.

CONCLUSION

The study concluded that the glycemic response of the commonly consumed Pakistani beverage *Jam-e-Shirin* can be substantially lowered through the incorporation of dietary fiber. The addition of soluble fiber effectively reduced its potential to elevate postprandial blood glucose, highlighting the role of fiber as a simple yet powerful dietary intervention for improving glycemic control. These findings emphasize that enriching sweetened beverages with dietary fiber may serve as a practical nutritional strategy to help prevent the progression from normal glucose tolerance to prediabetes and diabetes within the general population.

AUTHOR CONTRIBUTION

Author	Contribution
Asif Ahmad Khan	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Muhammad Anis	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing Has given Final Approval of the version to be published
Ayaz Ahmed	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published
Zohaib Ahmad	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Zahoor Ahmad	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Abdur Rehman*	Substantial Contribution to study design and Data Analysis Has given Final Approval of the version to be published

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