Research Article

Queen Arwa University Journal

مجلة جامعة الملكة أروى

QAUSRJ

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Organization/University/ Center:

Affiliation: *Queen Arwa University*

Research funder: *Not found.*

Research field/specialization:

Nutrition and Dietetics.

QR code:

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امسح الكود لزيارة موقع المجلة

Evaluation of Glycemic Index and Glycemic load of some Traditional Yemeni Foods

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2025

Abstract:

The aim of this study was to evaluate the glycemic index (GI) and glycemic load (GL) of five traditional Yemeni foods: Sabaya, Malouj, Lahouh, Al-Zum, and Fahsa. All food samples were obtained from local markets in Sana'a, transported under controlled conditions, and analyzed in the laboratory of Queen Arwa University. Fifteen healthy volunteers aged 18–25 years consumed measured portions of each food and a reference glucose solution after an overnight fast. Blood glucose was measured at before eating (0) minutes and 30, 60, 90, and 120 minutes after consumption, with GI calculated from the incremental area under the glucose response curve and GL derived from standard formulas. Results showed wide variation in GI, from 30.59% for Fahsa to 75.88% for Lahouh. High-GI Lahouh elicited the fastest postprandial glucose rise, likely due to refined flour, high carbohydrate content, and low fiber, whereas Fahsa, rich in protein and fat, had the lowest GI. Malouj and Sabaya displayed low GI, and Al-Zum showed medium GI, reflecting the moderating influence of dietary fiber. GL values were generally low (3.06–7.59), indicating modest glycemic impact from typical portions. LSD analysis ($p < 0.05$) revealed that most pairwise GI differences were statistically significant, highlighting distinct postprandial responses. These findings suggest that, despite variability in GI, traditional Yemeni foods have low GL and can be included in diets aimed at maintaining stable blood glucose and promoting metabolic health.

Keywords:

Glycemic index, Glycemic load, traditional Yemeni foods, sabaya, Malouj, lahouh, al-zum, fahsa, diabetes, blood glucose.

Evaluation of Glycemic … Traditional Yemeni Foods, Alsebaeai et al., Index of Tables
Queen Arwa University Journal Vol. 30 No. 30 (2025)

جامعة الملكة أروى

1. Introduction

Traditional foods are an integral part of cultural identity and daily diets worldwide, providing not only energy but also essential nutrients required for optimal health. In Yemen, traditional dishes such as Sabaya, Malouj, Lahouh, Al-Zum, and Fahsa are widely consumed, yet there is limited information regarding their nutritional composition and metabolic effects. Recent studies have highlighted the importance of evaluating the chemical composition of these foods to understand their contributions to dietary intake. For instance, Alsebaeai et al., (Alsebaeai, Al-Rahbi, et al., 2025) reported significant variations in moisture, protein, fat, carbohydrate, and caloric content among these Yemeni dishes, reflecting differences in ingredients and preparation methods. Sabaya, a high-fat dish, had the greatest energy content, while Al-Zum, a liquid-based dish, had the lowest caloric value, emphasizing the diversity of traditional Yemeni foods in supporting different nutritional needs.

The glycemic index (GI) is a widely recognized measure that evaluates the rate at which carbohydrate-containing foods elevate postprandial blood glucose levels (Ali et al., 2010; Amwoma et al., 2023). Understanding the GI of traditional foods is crucial, particularly for populations at risk of chronic diseases such as type 2 diabetes, where dietary management is essential for glycemic control. Studies conducted in the Middle East and East Africa have reported that traditional breads, rice dishes, and composite flours exhibit a wide range of GI values depending on their composition, preparation, and processing methods (Ali et al., 2010; Amwoma et al., 2023; Almousa, 2013). In Oman, traditional breads made from wheat flour showed low to medium GI values, whereas rice-based dishes displayed GI and glycemic load (GL) values influenced by cooking methods and ingredient composition (Ali et al., 2010). Similarly, date fruits, a staple in Arab diets, demonstrated GI variations according to the stage of ripeness, indicating the impact of food maturation on postprandial glucose responses (Alzahrani et al., 2023).

In Yemen and neighboring regions, research on the GI and GL of traditional foods remains limited, despite their widespread consumption and potential health implications. Characterizing the glycemic response of these foods can aid in the development of culturally appropriate dietary guidelines and

ترجمة الى العربية

تقدير المؤشر الجلايسيمي والحمل الجلايسيمي لبعض الأطعمة اليمنية الشعبية

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2025

الملخص

هدفت هذه الدراسة الى تقييم المؤشر الجلايسيمي (GI) والحمل الجلايسيمي (GL) لخمسة أطعمة يمنية تقليدية: سبايا، ملوج، لَحوح، الزوم، والفحسة. تم الحصول على الأطعمة من الأسواق المحلية في صنعاء، ونُقلت تحت ظروف مضبوطة، وحللت في مختبرات جامعة الملكة أروى. تناول خمسة عشر متطوعاً صحياً تتراوح أعمارهم بين 18 و25 عاماً كميات محددة من كل غذاء والجلوكوز بعد صيام ليلة كاملة. تم قياس مستوى الغلوكوز في الدم عند 0، 30، 60، 90، و120 دقيقة، وتم حساب المؤشر الجلايسيمي من المساحة التزايدية تحت منحنى استجابة الغلوكوز، في حين تم اشتقاق الحمل الجلايسيمي من الصيغ القياسية. أظهرت النتائج تفاوتاً واسعاً في المؤشر الجلايسيمي، حيث بلغ 30.59% للفحسة و75.88% لِحَوح. اثر الملوح عالي المؤشر الجلايسيمي أسرع ارتفاع للغلوكوز بعد الوجبة، ويعود ذلك على الأرجح إلى الدقيق المكرر، وارتفاع محتوى الكربوهيدرات، وانخفاض الألياف، بينما كان للفحسة، الغنية بالبروتين والدهون، أقل مؤشر جلايسيمي. أظهر كل من الملوج والسبايا مؤشراً جلايسيمياً منخفضًا، وأظهر الزوم مؤشراً متوسطًا، مما يعكس التأثير المعتدل للألياف الغذائية. كانت قيم الحمل الجلايسيمي عامة منخفضة (3.06– 7.59)، مما يشير إلى تأثير جلايسيمي معتدل من الحصص الغذائية. أظهر تحليل LSD (p < 0.05) أن معظم الفروقات في المؤشر الجلايسيمي كانت ذات دلالة إحصائية، مما يبرز الاستجابات المختلفة بعد الوجبة. تشير هذه النتائج إلى أنه، بالرغم من تفاوت المؤشر الجلايسيمي، فإن الأطعمة اليمنية التقليدية تتميز بحمل جلايسيمي منخفض ويمكن إدراجها في الأنظمة الغذائية التي تهدف إلى الحفاظ على استقرار مستوى الغلوكوز في الدم وتعزيز الصحة الأيضية.

Evaluation of Glycemic ... Traditional Yemeni Foods, Alsebaeai et al., Index of Tables
Queen Arwa University Journal Vol. 30 No. 30 (2025)

جامعة الملكة أروى

interventions for the prevention and management of metabolic disorders. Additionally, fortification and functional modifications, such as the incorporation of dietary fiber or bioactive compounds, have been explored to enhance the nutritional quality of traditional foods without compromising their sensory appeal (Alsebaeai, Aldoubai, et al., 2025; Sonker et al., 2018).

Therefore, the determination of the glycemic index and Glycemic load of traditional Yemeni foods, including Sabaya, Malouj, Lahouh, Al-Zum, and Fahsa, is essential to bridge the existing knowledge gap. Such studies provide insights into the metabolic impact of these dishes, guide dietary recommendations, and support the integration of traditional foods into balanced diets that promote health while respecting cultural preferences.

2. Material and methods

2.1. Sample Collection and Transportation

Five traditional Yemeni foods—Lahouh, Sabaya, Fahsa, Al-Zum, and Maloje—were selected for the study based on their high reproducibility and widespread acceptability among the target population. The foods were obtained from popular restaurants in Sana'a, Yemen, which specialized in Yemeni cuisine and followed standardized recipes to ensure consistency in preparation. After collection, the food samples were transported under conditions that preserved their original preparation and stored at controlled cooling temperatures until analysis. This procedure ensured minimal alterations in chemical composition and maintained the quality of the foods for the glycemic index and Glycemic load testing. Main ingredients used in the preparation of five traditional foods commonly consumed in Yemen according to Alsebaeai et al., (Alsebaeai, Al-Rahbi, et al., 2025) as presented in table1.

Table 1 Main ingredients used in the preparation of five traditional foods commonly consumed in Yemen [1]

Dish	Main Ingredients
Lahouh	Wheat or Sorghum flour, Water, Yeast and Salt
Sabaya	White flour, Ghee or butter, Water, Salt
Fahsa	Cooked meat, Fenugreek paste (hilbah), Tomatoes, Garlic, Onions and spices
Al-Zum	Sorghum flour, Water, Yogurt or fermented milk and Salt
Malouj	White flour, Water, Yeast and Salt

2.2. Determination of GI

2.2.1. Sample size

The study included fifteen healthy volunteers' students aged 18–25 years (Almousa, 2013). All participants underwent comprehensive clinical, anthropometric, and laboratory evaluations to confirm their health status prior to inclusion in the study.

2.2.2. Study design

Participants were instructed to strictly follow the study protocol by consuming the assigned test or reference food as breakfast daily at 7:00 a.m. They were asked to abstain from any food intake between dinner and breakfast, allowing only water, mineral water, tea, or unsweetened coffee. Throughout the one-week testing period, participants were advised to maintain consistent physical activity levels and avoid smoking. To ensure compliance and accurate data collection, each participant kept a diary to record their food intake, exercise, and self-monitored blood glucose readings (Asinobi et al., 2016).

2.2.3. Healthy volunteers

The fifteen participants were healthy students their BMI ranged from (21-23kg/m^2). Thorough clinical and laboratory investigations were performed to establish that the volunteers were healthy.

2.2.4. Tested foods

The meals were professionally collected; the portions were packed and marked with a set sign. The traditional foods were taken for the experiment shown in the table (2). Glucose weighed 25 g and dissolved in 200 ml water before drinking according to (Almousa, 2013) with some modification.

Table 2: Quantities of Test Foods and Reference Glucose Used in the Experiment * [1]

Foods and Glucose	Carbohydrate %*	Portion Size (g)
Glucose		25
Fahsa	6.33	395
Lahouh	31.43	80
Sabaya	30.93	80
Malouj	63.09	40
Al-Zum	10.95	227.5

The Percentage of Carbohydrate on selected Yemeni foods were obtained from (Alsebaeai, Al-Rahbi, et al., 2025) Food portions were prepared

Evaluation of Glycemic ... Traditional Yemeni Foods, Alsebaeai et al., Index of Tables
Queen Arwa University Journal Vol. 30 No. 30 (2025)

جامعة الملكة أروى

professionally, packed, and labeled. For the reference food, glucose was weighed (25 g) and dissolved in 200 mL of water before consumption according to with some modification.

2.2.5. Blood sample collection

To determine the GI, each participant consumed a portion of the test food containing 25 g of available carbohydrates after an overnight fast. Capillary blood samples were collected via finger-prick at before eating (0 Minute) and 30, 60, 90, and 120 minutes after the start of the meal. Capillary blood glucose levels were measured using a portable glucometer (HEMOTOUCH Optium, manufactured by Freestyle) with manufacturer-provided test strips. The device was calibrated according to the manufacturer's instructions, plasma-equivalent values were recorded, and quality control procedures were performed to ensure measurement accuracy and minimize strip variability (Wolever et al., 2003; Hätönen et al., 2006; Fao/Who, 1998).

2.2.6. Blood Glucose Response Curves

For each food, the mean blood glucose concentrations of all participants were calculated and plotted against time to construct the two-hour postprandial blood glucose response curve.

2.2.7. Calculations of Glycemic Index (GI)

The glycemic index for each meal was determined by calculating the incremental area under the blood glucose response curve (iAUC) for the test food and dividing it by the iAUC of the reference food (glucose), then multiplying the result by 100. The mean GI of all participants was considered the GI of the test food (ISO, 2010)

2.2.8. Calculations of Glycemic Load (GL)

The glycemic load, which reflects the overall effect of a carbohydrate-containing food on postprandial blood glucose, was calculated by multiplying the GI of the test food by the amount of available carbohydrates in a typical serving and dividing by 100. This approach accounts for both the quality (GI) and quantity of carbohydrates in the food (Tabassum et al., 2013).

2.3. Data Analysis and Statistics

All data were analyzed using IBM SPSS Statistics 23 and are presented as mean ± standard deviation (SD). The effects of food type and time on postprandial blood glucose, incremental area under the curve (iAUC), glycemic index (GI), and glycemic load (GL) were evaluated using repeated measures analysis of variance (ANOVA), followed by LSD post hoc test to identify significant pairwise differences.

A P-value < 0.05 was considered statistically significant.

2.4. Ethical Considerations

This study was conducted in accordance with established ethical principles for research involving human participants. Ethical approval was obtained from QAU before the initiation of the study. All participants were informed about the purpose, procedures, and potential risks of the study, and written informed consent was obtained prior to participation. Participants were assured that their participation was voluntary and that they could withdraw from the study at any time without any consequences. Confidentiality and anonymity of the participants' information were strictly maintained, and all collected data were used solely for research purposes. Additionally, all procedures related to blood glucose measurement were carried out using safe and hygienic practices to minimize any risk or discomfort to participants.

3. Result and Discussion

3.1. Glycemic index of different Traditional food sample

3.1.1. Average blood glucose responses of volunteers on standard glucose and Lahouh

Figure 1 illustrates the dynamic changes in blood glucose levels over a 120-minute period following the consumption of a reference glucose solution and the traditional Yemeni food Lahouh. Before ingestion, the baseline blood glucose levels were 94.2 mg/dL for the glucose solution and slightly lower at 87.6 mg/dL for Lahouh, reflecting the initial absorption differences between simple and complex carbohydrates. At 30 minutes, the glucose solution caused a rapid rise to a peak level of 123 mg/dL, whereas Lahouh resulted in a more moderate increase, reaching 103.6 mg/dL, indicating a slower postprandial glucose response likely due to its fiber and fat content. By 60 minutes, glucose levels began to decline to 99.4 mg/dL, while Lahouh showed a slightly smaller reduction to 97.4 mg/dL, suggesting more gradual glucose clearance. At 90 minutes, blood glucose continued to decrease, with values of 88.4 mg/dL for glucose and 85.4 mg/dL for Lahouh, highlighting the prolonged stabilizing effect of Lahouh on blood sugar levels. By the end of the 120-minute period, both glucose and Lahouh converged to the same level of 84.8 mg/dL, indicating a return to near-baseline values..
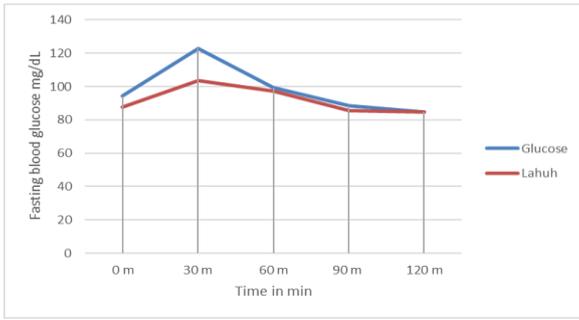
Evaluation of Glycemic ... Traditional Yemeni Foods, Alsebaeai et al., Index of Tables
Queen Arwa University Journal Vol. 30 No. 30 (2025)

جامعة الملكة أروى

Figure 1 : Average blood glucose responses of volunteers on standard glucose and Lahouh

3.1.2. Average blood glucose responses of volunteers on standard glucose and Fahsa food

Figure 2 presents the blood glucose response over 120 minutes following the consumption of Fahsa. Before ingestion, the baseline blood glucose level was 82 mg/dL. By 30 minutes, a slight increase to 83.4 mg/dL was observed, indicating a gradual initial rise in postprandial glucose. At 60 minutes, the blood glucose level reached 87 mg/dL, reflecting a moderate and delayed peak compared to high-GI foods. This was followed by a minor decline to 86 mg/dL at 90 minutes, suggesting slow glucose absorption and gradual metabolic processing. By the end of the 120-minute period, blood glucose slightly decreased to 85 mg/dL, remaining close to baseline levels. These results indicate that Fahsa elicits a slow and steady glycemic response, likely due to its high protein and fat content, which may help in maintaining stable postprandial blood glucose levels (Bell et al., 2015).
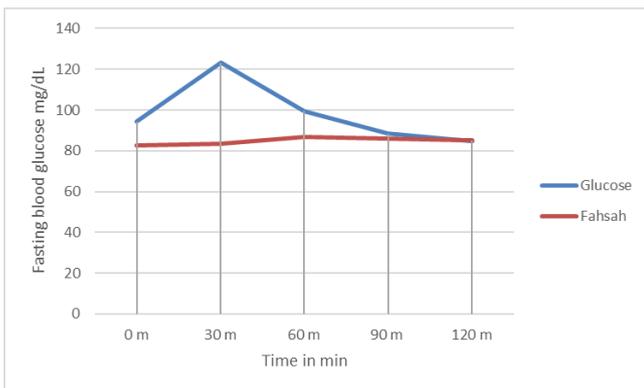

Figure 2: Average blood glucose responses of volunteers on standard glucose and Fahsa food

3.1.3. Average blood glucose responses of volunteers on standard glucose and Al-Zum

Figure 3 illustrates the blood glucose response over time following the consumption of glucose and Al-Zum. Blood glucose levels at Before ingestion were 92 mg/dL for Al-Zum. By 30 minutes, levels peaked at 123 mg/dL, indicating the highest postprandial response. At 60 minutes, blood glucose decreased to 104.8 mg/dL, followed by a further decline to 96.2 mg/dL at 90 minutes. Interestingly, at 120 minutes, blood glucose slightly increased to 97 mg/dL before returning closer to baseline at 89.8 mg/dL. This pattern suggests that Al-Zum produces a moderate and slightly delayed glycemic response compared to pure glucose, likely influenced by its composition, including moisture content, carbohydrates, and fat, which slow the absorption of glucose into the bloodstream (Shukla et al., 2017).
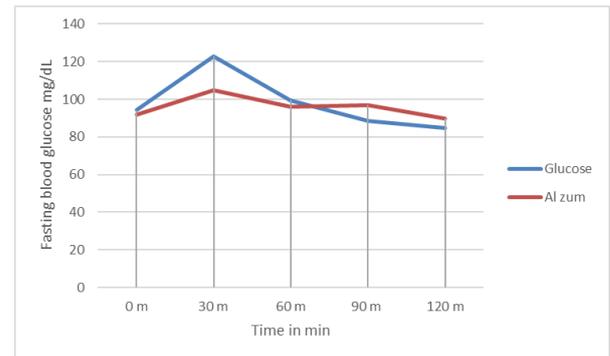

Figure 3: Average blood glucose responses of volunteers on standard glucose and Al-Zum.

3.1.4. Average blood glucose responses of volunteers on standard glucose and Malouj

Figure 4 depicts the blood glucose response over time following the consumption of glucose and Malouj. Blood glucose levels were 91.8 mg/dL at Before ingestion. By 30 minutes, levels rose to 96.6 mg/dL, reaching a peak of 100 mg/dL at 60 minutes. At 90 minutes, the blood glucose decreased slightly to 95.6 mg/dL, and by 120 minutes, it further declined to 90 mg/dL. These results indicate that Malouj produces a moderate and gradual postprandial glycemic response, reflecting its carbohydrate-rich composition and the influence of other macronutrients on glucose absorption (Gulati & Misra, 2025).
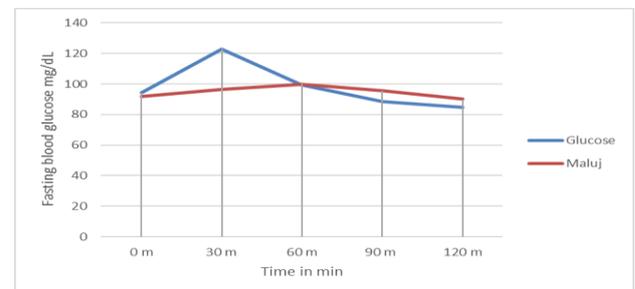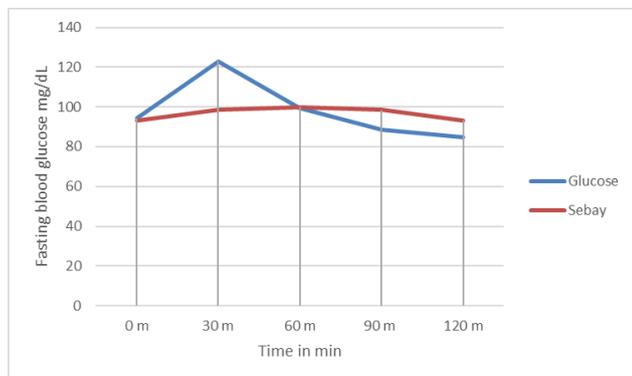

Figure 4: Average blood glucose responses of volunteers on standard glucose and Malouj.

3.1.5. Average blood glucose responses of volunteers on standard glucose and sabaya food.

Evaluation of Glycemic ... Traditional Yemeni Foods, Alsebaeai et al., Index of Tables
Queen Arwa University Journal Vol. 30 No. 30 (2025)

جامعة الملكة أروى

Figure 5 illustrates the blood glucose response over time following the consumption of glucose and Sabaya. Blood glucose levels at Before ingestion were 93 mg/dL. By 30 minutes, levels increased to 98.8 mg/dL and reached a peak of 100 mg/dL at 60 minutes. At 90 minutes, blood glucose slightly declined to 98.4 mg/dL, and by 120 minutes, it further decreased to 84.8 mg/dL.

Figure 5: Average blood glucose responses of volunteers on standard glucose and sabaya food

This pattern indicates that Sabaya elicits a moderate postprandial glycemic response, with a peak occurring around 60 minutes, likely influenced by its high fat and carbohydrate content, which may contribute to a slower absorption of glucose compared to pure glucose (Kaur et al., 2020).

3.1.6. Glycemic index of some traditional food

The Glycemic index of some Yemeni traditional food present in table 4. The GI values ranged from 30.59% for Fahsa to 75.88% for Lahouh, indicating considerable variability in postprandial glucose response. Lahouh, classified as a high-GI food, elicited the most rapid rise in blood glucose, likely due to its high carbohydrate content, refined flour, and low fiber composition, consistent with previous findings on Yemeni flatbreads (Alsebaeai, Al-Rahbi, et al., 2025). In contrast, Fahsa, a protein- and fat-rich dish, showed the lowest GI, supporting evidence that protein and fat slow gastric emptying and reduce glucose absorption (Jenkins et al., 2002).

Malouj and Sabaya exhibited low GI values (49.41% and 53.82%, respectively), while Al-Zum had a medium GI (64.71%), reflecting the moderating effect of dietary fibers, similar to cereal-based regional foods (Ali et al., 2010; Thondre et al., 2011). The Least Significant Difference (LSD) test (p < 0.05), indicated that all pairwise differences in glycemic index among the selected foods were statistically significant. This means that each food produced a distinct postprandial glycemic response, confirming that variations in carbohydrate composition and macronutrient content lead to measurable differences in blood glucose levels.

Table 3: Glycemic index of some traditional food

Samples	Mean GI ± SD	GI classification
Malouj	49.41±2.12[a]	Low GI
Sabaya	53.82±1.56[b]	Low GI
Lahouh	75.88±1.01[c]	high GI
Fahsa	30.59±2.02[d]	Low GI
Al-Zum	64.71±3.21[e]	Medium GI

*Mean ± Standard deviations (n = 15).

Means in the same column with different upper-case letters are significantly different (*P* < 0.05).

3.1.7. Glycemic load of some traditional food

The glycemic load (GL) of the selected traditional Yemeni foods was generally low, ranging from 3.06 for Fahsa to 7.59 for Lahouh (Table 4). This indicates that, although some foods such as Lahouh have a high glycemic index (GI), their overall impact on postprandial glucose is modest when consumed in typical portion sizes. Lahouh, with the highest GL, corresponds to its high GI and rapid glucose-raising potential, which is consistent with studies on refined Yemeni flatbreads (Alsebaeai, Al-Rahbi, et al., 2025). In contrast, Fahsa, a protein- and fat-rich dish, had the lowest GL, reflecting the glucose-modulating effect of dietary protein and fat (Jenkins et al., 2002). Malouj, Sabaya, and Al-Zum exhibited intermediate GL values (4.94, 5.38, and 6.47, respectively), which are consistent with their low-to-medium GI values, indicating moderate postprandial glucose responses (Ali et al., 2010; Thondre et al., 2011). These findings suggest that, despite differences in GI, the traditional Yemeni foods tested generally have a low glycemic load, making them suitable for inclusion in diets aimed at maintaining stable blood glucose levels and managing metabolic health.

Table 4: Glycemic load of some traditional food

Samples	Mean GI ± SD
Malouj	4.94±0.45a
Sabaya	5.38±0.63 a
Lahouh	7.59±0.11b
Fahsa	3.06±0.03c
Al-Zum	6.47±0.27d

*Mean ± Standard deviations (n = 15).

Means in the same column with different upper-case letters are significantly different (P < 0.05).

The LSD analysis confirms that traditional Yemeni foods vary significantly in their glycemic effects, highlighting the importance of considering food composition and carbohydrate quality when planning diets to manage postprandial blood glucose. The finding that some foods (Malouj and Sabaya) are not significantly different suggests that small variations in preparation or ingredient

Evaluation of Glycemic ... Traditional Yemeni Foods, Alsebaeai et al., Index of Tables
Queen Arwa University Journal Vol. 30 No. 30 (2025)

جامعة الملكة أروى

composition may not markedly affect glycemic response.

4. Conclusion

The findings of this study indicate that traditional Yemeni foods exhibit considerable variability in glycemic responses, with Lahouh eliciting the highest postprandial glucose levels and Fahsa the lowest. Despite these differences, the glycemic load of all foods, based on typical portion sizes, was generally low, suggesting a moderate overall impact on blood glucose. Statistical analysis using the LSD test ($p < 0.05$) confirmed that most pairwise differences in glycemic index were significant, reflecting distinct postprandial responses among the foods. These results underscore the influence of carbohydrate composition and macronutrient content—particularly protein, fat, and dietary fiber—on glycemic outcomes. The study supports the inclusion of these traditional Yemeni foods in dietary strategies aimed at stabilizing blood glucose and promoting metabolic health.

5. Study Limitations

This study has several limitations. The small sample size of fifteen healthy young adults limits generalizability, and only five traditional Yemeni foods were evaluated, which may not represent the full dietary diversity. Despite standardized preparation, variations in ingredients and cooking methods could have affected GI and GL measurements. Postprandial glucose was monitored for only two hours, and capillary blood measurements using a portable glucometer may be less precise than laboratory assays. Additionally, individual differences in digestion, hormones, and gut microbiota were not controlled. Future studies should include larger, more diverse populations, additional foods, and longer monitoring periods to better understand the glycemic impact of Yemeni traditional foods.

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Evaluation of Glycemic ... Traditional Yemeni Foods, Alsebaeai et al., Index of Tables
Queen Arwa University Journal Vol. 30 No. 30 (2025)

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Index of Tables

Index of Figures

Contents

Evaluation of Glycemic ... Traditional Yemeni Foods, Alsebaeai et al., Contents
Queen Arwa University Journal Vol. 30 No. 30 (2025)

جامعة الملكة أروى