International Journal of Nutrition and Food Sciences
2024, Vol. 13, No. 4, pp. 140-146
https://doi.org/10.11648/j.ijnfs.20241304.12

Research Article

Glycemic Index Evaluation of Flaxseed Oats Sourdough Bread

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Abstract

Background: Glycemic index (GI) is a numerical system that ranks carbohydrate-containing foods by how much they raise blood glucose level. Understanding GI is beneficial in diet management, especially for weight loss or diabetic people. Various types of food, such as functional foods, have recently gained attention for their health benefits, with sourdough bread being a notable example. As sourdough bread becomes a preferred option for weight and diabetes management, disclosing its glycemic index is crucial. *Objective:* This study aims to assess the glycemic index of a newly available bread, the flaxseed oats sourdough bread. *Methodology:* Ten healthy subjects aged between 23 to 37 years old were recruited (mean 28.7 ±4.4 years) and required to fast and then consume 50 g of available carbohydrate portions of test and reference foods. Finger capillary blood samples were collected at the start (fasting, 0 minute) and 15, 30, 45, 60, 90 and 120 minutes after consumption. The GI was calculated from the ratio of incremental area under the curve (iAUC) to reference food. *Result:* The results show that flaxseed oats sourdough bread has a GI of 37.3 which is classified as low GI. *Conclusion:* Determining the GI value of this bread provides valuable data that can enhance dietary recommendations for weight and diabetes management. Implementing a low GI diet nationwide necessitates ongoing research, public education, and collaboration with food manufacturers to ensure consumers have access to healthier carbohydrate options.

Keywords

Glycemic Index, Bread, Sourdough, Diabetes, Obesity, Weight Management, Postprandial Blood Glucose, Malaysia

1. Introduction

Diabetes is a chronic medical condition marked by high blood glucose levels due to the body's inability to produce or effectively use insulin, a hormone that regulates blood sugar [1]. According to the World Health Organization [2], the number of people with diabetes increased from 108 million in 1980 to 422 million in 2014, with prevalence rising more rapidly in low and middle-income countries than in high-income countries. The recent National Health Morbidity Survey by Ministry of Health, Malaysia reported that 15.6% of Malaysians have diabetes, and 84% of young adults aged 18-29 are unaware of their condition [3]. Over time, diabetes can lead to complications such as damaged blood vessels, kidney failure, stroke, and permanent vision loss [4]. Early diagnosis and effective management are essential to preventing or delaying complications and maintaining a good quality of life for those with diabetes.

Diabetic individuals often struggle to manage postprandial blood glucose without medical treatment and this challenge

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Received: 18 June 2024; **Accepted:** 5 July 2024; **Published:** 23 July 2024

arises because their bodies neither produce enough insulin nor effectively use the insulin they produce [5]. Exploration and understanding the glycemic index (GI) of foods is a useful tool in managing postprandial blood glucose concentrations [6]. A meta-analysis study by Zafar et al. [7] documented that low GI diets are effective in reducing HbA1c, blood glucose levels, and body weight in individuals with prediabetes and diabetes. In contrast, high GI foods, which are considered poor-quality carbohydrates, were associated with an increased risk of cardiovascular disease and mortality [8]. Meanwhile, low GI foods are widely recognized for their significant role in preventing chronic diseases [9]. In addition to GI, several other indicators are commonly used to assess the quality of carbohydrate foods. These indicators include dietary fiber content, added sugars, and nutrient density, as highlighted by Nicholls et al. [10].

One of the popular choices for carbohydrate sources is bread and it is a fundamental food in many diets worldwide, including Malaysia. As a versatile and convenient food item, it has become a popular substitute for rice, which is traditionally the staple food in Malaysian cuisine [11]. It is predominant to understand the role of bread in the diet and its impact on health, particularly for individuals managing weight and blood glucose. Wholemeal bread is typically considered a healthier option than white bread due to its lower GI, however, nowadays, sourdough bread has gained popularity among health-conscious individuals due to its unique fermentation process, which offers various health benefits. It also has a lower GI, enhanced nutrient availability, and better digestibility compared to conventional breads [12].

The recipe and process of baking breads varies, impacting their GI values and making it challenging to provide standardised recommendations for weight and diabetes management [13]. Hence, clarifying the GI value of specific breads is crucial for making informed dietary choices. In order to address this need, this study was conducted to determine the GI value of flaxseed oats sourdough bread.

2. Methodology

2.1. Subjects

Sixteen healthy volunteers were recruited to participate in the study. Three subjects were excluded because they were unable to comply with the study protocol, and another three did not meet the inclusion criteria. Subjects were screened for body weight, body mass index (BMI), HbA1c and fasting capillary blood glucose. Inclusion criteria were: (1) normal BMI (BMI ≤24.9 kg/m^2), (2) HbA1c level <5.7% [14], normal fasting glucose level (4.4-7.0 mmol/L), (4) non-smoker, (5) not taking any medication that can affect glucose metabolism and (5) did not practice any special diet or physical activity at least a month prior data collection. Exclusion criteria were: (1) pregnant or lactating females.

2.2. Study Design and Experimental Procedures

In this open label study, glucose (Glucolin™) is the reference food against the tested foods: commercial brand whole-meal and flaxseed oats sourdough bread. This study took place in Alpro Academy Laboratory and subjects reported attendance at 8.00 am to 9.00 am in the morning after at least 10-12 hours of overnight fasting. Prior to the recruitment, data was collected using a questionnaire form, then fasting blood glucose and HbA1c (Cobas b 101, Roche, Switzerland) were also tested. Afterwards, each subject was required to consume an equivalent of 50 g available carbohydrate of reference and test food within 10-15 minutes, with a washout period of two days for each test food. The subjects were instructed to maintain their usual daily food intake and physical activity throughout the study period. The nutrient content of the tested food is indicated in Table 1. The glucose powder was dissolved with 250 ml of water. Finger-prick capillary blood samples were collected using Microlet® lancet and blood glucose was evaluated using Contour® Plus One glucometer (Ascensia, Switzerland). The blood samples were collected fasting (0 minute) and 15, 30, 45, 60, 90 and 120 minutes after the consumption of reference and test foods.

Table 1. *Amount of energy and nutrients of the test breads for each 50 g available carbohydrate consumed.*

Nutrients	Wholemeal	[a]Flaxseed oats sourdough
Energy (kcal)	311	339
Carbohydrate (g)	50	50
Protein (g)	18	25
Fat (g)	4	8
Dietary fibre (g)	8	14

[a]The nutrient analyses were carried out by the approved laboratory and samples were analysed using Method of Analysis for Nutrition Labelling, Chapter 1, 1993. Carbohydrate was determined by proximate analysis.

2.3. Statistical Analysis

Data were analysed using SPSS (IBM SPSS Statistic v.27, Chicago, IL, USA). Descriptive statistics are expressed as mean ± sd. Kruskal-Wallis H test was employed to determine significant differences of non-parametric data. A value of $P<0.05$ was considered significant.

2.4. Glycemic Index Determination

The area under curve (AUC) was calculated as the incremental area under the curve (iAUC) which was plotted and determined using trapezoidal methods in Microsoft Excel 2021. All AUC below the baseline value were eliminated in the summation. The average iAUC for the tested food, flaxseed oats sourdough bread, was calculated over reference food, glucose (GI=100%).

2.5. Ethics

This study had been approved by the ethics committee of Alpro Academy. The purpose and protocol of the study were explained to the subjects and informed consent was obtained before enrolment.

3. Results

3.1. Subjects' Characteristics

A total of 16 volunteers were involved in the study, of whom three were unable to comply with the study protocol, and another three were excluded for being discovered to have higher HbA1c level, leaving a total of ten subjects in the final analysis. Of the ten who were included, three (30%) were males and seven (70%) were females. The subjects' age ranged between 23 to 37 years old with mean age 28.7 ± 4.4 years. All subjects have a normal Body Mass Index (BMI) with mean 22.0 ± 2.2 kg/m^2. Normal hemoglobin A1c (HbA1c) readings were recorded, with a mean of 5.4% ±0.1%. Table 2 presents the background characteristics of the subjects. All of the subjects did not take any prescribed medication as well as implying any variation on daily diet or physical activity.

Table 2. *Background characteristics of the subjects.*

Characteristics	Mean ± s.d.	Range
Age (years)	28.7 ± 4.4	23 - 37
Weight (kg)	59.0 ± 8.9	47 - 76
Height (cm)	163.5 ± 0.8	153.0 - 176.0
BMI (kg/m^2)	22.0 ± 2.2	18.8 - 24.8
HbA1c (%)	5.4 ± 0.1	5.2 - 5.6

3.2. Blood Glucose Response and GI Value

Figure 1 represents the changes in blood glucose concentrations from baseline over 120 minutes for the tested foods. As shown in Table 3, the baseline fasting blood glucose before consuming different test foods (glucose, wholemeal and flaxseed oats sourdough bread) did not differ significantly ($P>0.05$). Significant increase in blood glucose level started at 15 minutes. The differences in postprandial blood glucose levels were consistently higher with the consumption of reference food, from 15 to 90 minutes time. The 120 minutes postprandial glucose reading was recorded higher for the test foods (6.2 ± 0.9 and 5.9 ± 0.7 mmol/L for wholemeal and flaxseed oats sourdough bread respectively) over reference food (5.6 ± 1.7 mmol/L) however the data was found not significant.

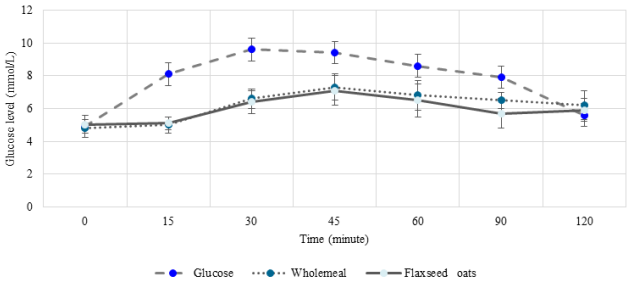

Figure 1. *Blood glucose responses at various time points after consuming reference and test foods.*

The trapezoidal method was used to calculate the AUC values for the reference and test foods, which were then utilised to determine the GI. Figure 2 illustrates the iAUC comparison of the foods. The iAUC reflects the changes occurring in blood glucose levels over the 120 minutes (2 hours) after consuming different foods. As indicated in Table 4, the mean AUC was higher for the reference food and the commercial wholemeal compared to the flaxseed oats sourdough bread. Consequently, the GI of flaxseed oats sourdough bread was determined to be 37.3%, the lowest among the test foods, classifying it as a low GI food. The GI value difference was also found to be significant ($P<0.05$).

Table 3. Blood glucose response of subjects (presented as mean ± s.d.).

[a]Time	0	15	30	45	60	90	120
G	4.9±0.4	8.1±1.2	9.6±1.3	9.4±1.8	8.6±2.2	7.9±1.8	5.6±1.7
WM	4.8±0.3	5.0±0.5	6.6±0.6	7.3±0.8	6.8±0.9	6.5±0.5	6.2±0.9
FO	5.0±0.3	5.1±0.4	6.4±0.7	7.1±0.9	6.5±1.0	5.7±0.9	5.9±0.7
P	0.435	0.001**	0.001**	0.001**	0.044*	0.002**	0.706

[a]Time in minute; G – Glucose; WM – wholemeal; FO – Flaxseed oats sourdough.

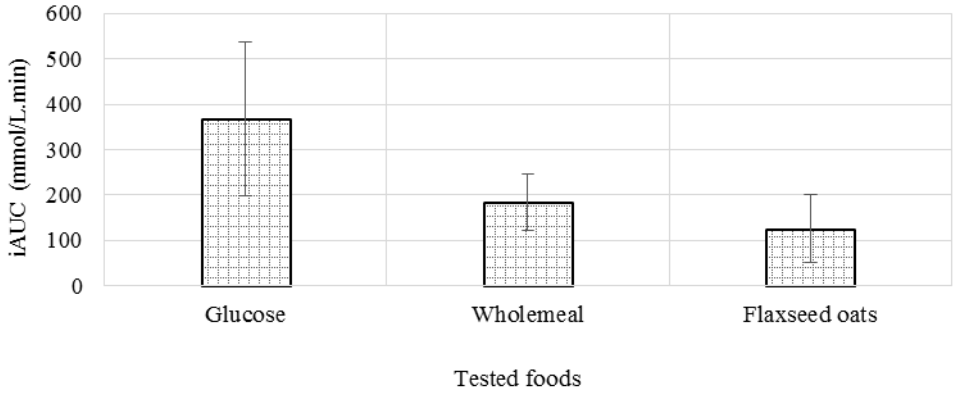

Figure 2. Comparison of iAUC mean value between tested foods.

Table 4. AUC and GI of tested and reference foods.

Test foods	iAUC (mmol/L.min)	GI (%)	P value
Glucose	368.5 ±170.3	100.0 ±0.0	
Wholemeal	183.5 ±62.5	57.0 ±29.3	*0.001
Flaxseed oats	126.7 ±74.1	37.3 ±19.9	

*P<0.01 using Kruskal-Wallis H test

4. Discussion

This study aimed to determine the GI value of flaxseed oats sourdough bread. The results indicate that it has a low GI (GI = 37), which is lower than that of commercial wholemeal bread (GI = 57). GI values are classified into three categories: low (GI < 55), intermediate (GI = 56-69), and high (GI > 69) [15].

As Malaysia's diet evolves, bread has increasingly become a preferred source of carbohydrates [11]. Carbohydrate-containing foods are crucial components of a healthy dietary pattern, providing essential energy and nutrients. However, they are often viewed with caution, with some experts recommending reduction or avoidance to manage health issues like obesity and diabetes [15]. One of the indicators of good quality carbohydrates is GI. The GI is based on a food's available carbohydrate and can be influenced by food processing and preparation methods [16].

Sourdough fermentation is the oldest method of dough fermentation [17]. In recent years, sourdough bread has gained significant attention, especially among health-conscious individuals. Basically, the dough preparation is a mixture of flour and water, with small amounts of salt, sugar, and butter or other types of fats. Afterwards, the mixture will be spontaneously fermented by a diverse colony of native lactic acid bacteria and yeast [18]. Lactic acid fermentation can improve the properties of these ingredients and enhance the sensory characteristics of the final products thus can be used as dietary interventions for seeking health benefits [19].

The interaction of ingredients during fermentation affects their bio-accessibility and bioavailability, which are crucial for the health benefits of the final product. [20]. In this context, sourdough can lower the GI of bread, release bioactive peptides and enhance the absorption of minerals, vitamins and phytochemicals. Additionally, the microbial metabolism present in the dough produces new nutritionally active compounds such as peptides and potentially prebiotic exopolysaccharides thus making the food easier to digest [21].

Compared to the available commercial brand of wholemeal bread, the flaxseed oats sourdough bread was found to have lower GI. Various factors can influence the GI value, with dietary fibre being a well-known factor that can improve carbohydrate quality. In food industry, adding fibre is the main strategy used for lowering the GI of a bread [22]. The dietary fibre content in the flaxseed oats sourdough bread was almost double than the commercial wholemeal bread content (14 g versus 8 g, per 50 g of carbohydrate), which might contribute to the difference. In terms of types of fibre, soluble forms have been reported to have effect in the attenuation of blood glucose response [23]. More precisely, flaxseed oats sourdough bread contains organic rolled oats which could be the reason for its lower GI, as oats products have been shown to elicit more favourable blood glucose response [24].

The findings also aligned with the evidence reported by Rolim et al. [25], indicating that sourdough is effective in reducing postprandial glycaemia, particularly when prepared with wholemeal flour. Incorporating such grains into products can preserve food particles in the gastrointestinal tract and slow stomach emptying, thus reducing the glycaemic response [26]. In this study, the tested bread contains a combination of wholemeal flour and other grains, which further improves carbohydrate quality and consequently affects the GI value.

Food processing may also alter the blood glucose response to a particular food. Processing conditions impacts postprandial glucose responses to starch by breaking down the cell wall and granule structure, with gelatinization increasing the GI [27]. A study by Lau et al. [28] documented that using the same bread recipe, varying processing conditions such as mixing time, mixing intensity, proofing period, and cooking method, resulted in lower starch digestibility in vitro and significantly affected the physical structure, thereby reducing the glycaemic response.

Additionally, the flaxseed oats sourdough bread is high in protein, containing about three times the amount of protein compared to the wholemeal bread (25 g versus 18 g per 50 g of carbohydrate). This finding suggests that the protein content affects the GI of the bread. This is aligned with a study by Lanzerstorfer et al., [29], which reported that protein-enriched bread possesses a low GI and increasing protein content can successfully reduce the GI of bread. This is related to the gluten content of some cereals which can limit starch bioavailability and enzyme accessibility, causing slower absorption of the carbohydrate [30]. This finding indicates that the postprandial glucose response is determined not only by carbohydrate content but also by the overall nutrient composition of the bread.

Although this study is limited to these two types of bread, the findings warrant closer attention to raise awareness about making better dietary choices, distinctly for managing body weight and diabetes. Additionally, the database of GI values of food and sourdough bread in Malaysia is still limited. Therefore, this study not only aims to improve individuals' diet selections but also contributes to building a comprehensive GI list for Malaysian foods.

5. Conclusions

In this study, the flaxseed oats sourdough bread was categorised as low GI food. Determining the GI value of this bread provides valuable data that can enhance dietary recommendations for weight and diabetes management. This study not only helps in clarifying the GI value of a specific bread but also underscores the need for more comprehensive GI data for various breads available in the market. Implementing a low GI diet in the country requires continued research, public education, and collaboration with food manufacturers to ensure consumers have access to healthier carbohydrate choices. Furthermore, studies on sourdough bread are suggested to explore the health benefits of this functional food.

Abbreviations

BMI	Body Mass Index
GI	Glycemic Index

Acknowledgments

The authors would like to extend this acknowledgement for Yooky Bakery Sdn. Bhd., research enumerators and all volunteers for their participation.

Author Contributions

Sa'ida Munira Johari: Conceptualization, Data curation, Formal Analysis, Writing – original draft, Writing – review & editing

Chua Kai Jia: Conceptualization, Methodology, Resources, Supervision

Khoo Wei Jin: Investigation, Project administration, Resources

Low Shu Yeng: Formal Analysis, Resources

Funding

This work is not supported by any external funding.

Data Availability Statement

The data is available from the corresponding author upon reasonable request.

Conflicts of Interest

The authors declare no conflicts of interest.

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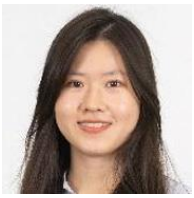
Biography

Sa'ida Munira Johari is a community dietitian in Alpro Pharmacy, graduated with Bachelor of Dietetics (Hons) in 2009 and Master of Health Sciences (Dietetics) in 2012 both from Universiti Kebangsaan Malaysia. Driven by a desire to deepen her expertise and make a more significant impact in the field of nutrition and dietetics, during her graduate studies until now, she actively involved in several research projects focusing on community nutrition, dietary interventions for chronic disease management, and the development of sustainable dietary practices.

Chua Kai Jia graduated from International Medical University (IMU) in year 2013 and started her career as a Dietitian in Hospital. She then pursued an MBA and continue her career as a community dietitian at Alpro Pharmacy. She is a member of Malaysian Dietitian's Association (MDA) and recently received the Special Recognition Award from MDA. She has special passion in Diabetes Management which ended her in the SugO365 team. SugO365 is a program to help Diabetic community achieve their health target through sustainable lifestyle changes.



Khoo Wei Jin is a community dietitian at Alpro Pharmacy. She earned her BSc (Hons) in Dietetics with Nutrition from the International Medical University (IMU) in 2022. At Alpro Pharmacy, she provides personalized dietary consultations, assisting individuals in managing diabetes through effective strategies. With a strong interest in diabetes management, she supports projects benefiting the diabetes community, dedicated to making nutrition knowledge accessible and enhancing non-communicable disease (NCD) management.

Low Shu Yeng is a community dietitian with Alpro Pharmacy Sdn Bhd. She completed her degree in Dietetics with Nutrition from International Medical University in 2021. She is also a registered dietitian under the Allied Health Professions Act 2016. She is committed to serving the community by sharing her expertise in preventative care and non-communicable diseases. As a member of the Malaysian Dietitians' Association, she actively promotes health and well-being through education and guidance. With a passion for empowering others to make informed dietary choices, she strives to prevent health issues before they arise, emphasizing the importance of nutrition in maintaining overall wellness.