Original Article

Glycemic index and glycemic load of multigrain chapatti (Indian flatbread) in healthy adult individuals

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Abstract

Introduction: Chapatti is a common Indian breakfast cereal-based preparation prepared from whole wheat flour and is consumed as a staple in various parts of India, especially North India. A multigrain chapatti developed and glycemic index (GI) and glycemic load (GL) of both preparations are analyzed to find out whether high fiber, high protein ingredients interfere with the glycemic response.

Methodology: Seventeen healthy adult men and women non-pregnant and non-lactating (18–45 years) were selected to volunteer the study. GI values were assessed using the standard method suggested by FAO/WHO 1998 (1). Participants in three different sessions were served with reference food i.e., aqueous solution of glucose, basic chapatti (made with 100% whole wheat flour) as reference food and multigrain chapatti (made with 70% whole wheat flour mixed with other grains, namely oats, soya bean, psyllium husk, jowar, and green gram dhal). Multigrain chapatti recipe was first standardized for the accuracy. Blood glucose concentration was analyzed using the one-prick finger capillary glucose analyzer in fasting state (0 min) and 15, 30, 45, 90, and 120 min, respectively, after ingestion of test food, GI was then calculated, and relative difference between GI of test and reference food was calculated, and statistical difference among different food was analyzed.

Results: The GI value of the test food (multigrain chapatti) resulting from the analyses was 45.61 ± 18.06 for (104 g corresponding to 50 g available carbohydrate), and the GL value was 4.88 per serving, i.e., 30 g, which is comparably less when compare to basic chapatti made with 100% wheat flour (i.e., 94.95 g of wheat flour corresponding to 50 g available carbohydrate) 61.41 ± 21.37 and GL for one serving, i.e., 30 g, 9.45 ± 2.

Conclusion: Inclusion of high fiber, nutrient-dense ingredients to recipe-like chapatti can be encouraged at the community level for improving dietary adequacy. These results can be considered as guidelines in the development of the healthy nutrient-dense product for consumers keen to pick healthy alternatives to their diets.

Keywords: Glycemic index, glycemic load, multigrain chapatti, oats, psyllium husk

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Submitted: 10-Apr-2020 **Revised:** 15-Apr-2020 **Accepted:** 17-Apr-2020 **Published:** 17-Jun-2020

INTRODUCTION

Glycemic response in blood following the ingestion of food is a normal physiological phenomenon, depends on the amount of glucose present in bloodstream/circulation and amount of glucose absorbed, the rate of disappearance from the circulation due to the tissue uptake.[1] Postprandial rise in blood glucose level may vary from one food to another, even with the same amount of carbohydrate present in the given food item,[2,3] this response

Access this article online	
Quick Response Code:	Website: www.ijfans.org
	DOI: 10.4103/IJFNS.IJFNS_10_20

How to cite this article: Nasreen S, Zubaida A. Glycemic index and glycemic load of multigrain chapatti (Indian flatbread) in healthy adult individuals. Int J Food Nutr Sci 2020;9:16-9.

is complex, which drives the attention of many investigators to study quality rather than the quantity of carbohydrates. Wolver and Jenkins in 1981 introduced the concept of glycemic index (GI) and glycemic load (GL). They represented GI as an indicator to classify carbohydrates according to their ability to raise postprandial blood glucose response.[4] GI describes the blood glucose response after consumptions of a carbohydrate-containing food item (the test food) in comparison to a carbohydrate-containing reference food (glucose or white bread) measured under standard conditions (FAO/WHO 1998). The concept of GI further extended to take onto consideration effect of total amount of carbohydrate ingested.

The GI of the food can be defined as the incremental area under the blood glucose response curve (AUC) of a 50 g available carbohydrate portion of a test food consumed by an individual under standard conditions expressed as the percentage of the AUC following consumption of reference food (50 g either glucose solution of white bread) consumed by the same person on a different day.[5] Whereas GL is defined as the product of the GI value of food and its carbohydrate content; GL incorporates both quality and quantity of carbohydrate consumed.

Foods can be categorized according to GI as low GI low (GI ≤ 55), medium (GI 56–69), and high (GI ≥ 70), and GL classifies food as low (GL ≤ 10), medium (GL 11–19), and high (GL ≥ 20).

The present study was undertaken to measure GI and GL of developed multigrain chapatti (Indian flat bread). The ratio of multigrain with wheat flour was set as 30:70. Very strong functional foods[1] such as germinated soybean flour, psyllium husk, oat flakes along with green gram dhal, and sorghum were selected for developing multigrain chapatti.

METHODOLOGY

Study design

Seventeen volunteers (18–45 years) clinically healthy, active individuals men (n = 3) and women (n = 14) non-pregnant and non-lactating were recruited for the study by random sampling techniques depending on positive response of participants to volunteer the study. Criteria for inclusion was the absence of clinical symptoms related to GI disorders, metabolic disorders as determined by filled in questionnaires. None of the participants had reported allergies toward the ingredients used in the test meal. All participants were recruited to study in accordance to the WHO and FAO 1998 GI testing protocol (WHO/FAO 1998).

Measurement of glycemic index and glycemic load

Ethical approval

The study reviewed and approved by an independent ethical review committee. The present study was conducted in Hyderabad city, India. After recruiting participants to the study, written consent was obtained from them to ensure their participation in the study.

A self-administered questionnaire was given to all participants to find out their medical history, food allergies, and socioeconomic and educational background.

Screening of the subjects

All participant's anthropometry assessment was done; their height was noted down using stadiometer and weight was noted down using the digital-weighing balance (Geepas Personal Scale GB4169) Body mass index (BMI) values were obtained to determine the BMI of participant's their height and weight values were used and further inserted in a formula weight (Kg) divided by the square of height (m^2) usually expressed as Kg/m^2.[6]

Twenty-four hour dietary recall of all participants was also noted down and was further analyzed to find out mean dietary intake of nutrients, meal timing, and snacking options. Prior to glucose analyses, volunteers' blood pressure were calculated using the Omron digital sphygmomanometer, and body temperature was also noted down using the digital thermometer.

Reference and test meal

Fifty gram glucose mixed with 200 ml plain water was used as reference food and given to all participants after overnight fasting not more than 16 hours. A multigrain grain chapatti (Indian flatbread), having 70% whole wheat flour, 30% other grains, namely oats, sorghum (jowar), germinated soybean flour, and psyllium husk were used to make chapatti after incorporation of grains to wheat flour recipe of chapatti was further standardized. Basic recipe of chapatti (made of 100% wheat flour) used as reference food, whose GI was evaluated to compare with GI of multigrain chapatti. A low GI vegetable curry was given to all participants along with a test meal. After each session, 3 days gap was given as a wash off period.

Blood sampling procedure

Blood sample was drawn using one-touch finger-prick blood glucose analyzer (dr. Morepan glucometer) before meal and 15, 30, 45, 60, and 120 min after the meal.

Blood glucose analysis was done for three samples, glucose as the standard reference food, basic chapatti, and test food, i.e., (chapatti prepared with multigrain flour mix). All participants were provided with a test meal and instructed to make sure to consume this within 15 min. Blood samples were obtained at the interval of 15, 30, 45, 60, 90, and 120 minutes after baseline. The participants were instructed to stay within the testing area and engage themselves in some sedentary activities such as reading, sitting, or communicating.

Measurement of glycemic index and glycemic load

Among the various methods used for the measurement of GI, incremental area under the curve (iAUC) was adopted. In this method, iAUC refers to the area included between the baseline and incremental blood glucose points when connected by the straight lines. The area under each incremental glucose curve is calculated geometrically using the trapezoidal method for only the area above the baseline.

The glucose tolerance curve and the test meal curve were then compared, and the GI of the test meal was calculated using the following formula:[2]

$$GI = \frac{\text{iAUC for test meal}}{\text{iAUC for Reference food containing same amount of CHO}} \times 100$$

The glycemic load calculated using the formula

The concept of GL was first introduced in 1997 by the researchers at Harvard University to assess the glycemic effect of a portion of food in terms of quantity. Thus, GL of one serving food is the product of total available carbohydrate in one serving of the given food along with GI of the same food. More GL values indicate greater elevation or rise in blood glucose and insulinogenic effect of food.[3] GL of the multigrain mix was calculated using the following equation:

$$GL = \frac{\text{GI} \times \text{available Carbohydrate(g)}}{100}$$

RESULTS AND DISCUSSION

Demographic data represented in [Table 1] indicated that all participants had desirable weight and BMI during the study period.

24 hour dietary recall of all participants was analyzed and further compared with RDA suggested by ICMR, NIN 2010. Table 2 concluded that the intake of protein was far below than the recommendations made by the ICMR. Consumption of dairy products was also found to be lower than the recommendations. Whereas intake of fats and refined sugar was found to be higher when compare to RDA.

Reference meal and test meal

Mean glycemic response of standard and test meal was noted down [Table 3] and was individually plotted on the graph against time (blood glucose concentration (mmol/L vs. time (minutes) [Figure 1]. For each subject, iAUC values were calculated separately [Figures 2-4].

Table 1: Baseline anthropometric and physiological characteristics of participants (mean±standard deviation) (*n*=17)

Characteristics	Mean±SD
Age (year)	29.7±5.51
Height (cm)	157±6.79
Weight (kg)	59.3±10.49
BMI (kg/m^2)	24.11±4.04
Systolic blood pressure (mm/Hg)	112.35±9.03
Diastolic blood pressure (mm/Hg)	75.29±8

BMI: Body mass index, SD: Standard deviation

Table 2: Mean dietary intake of participants by 24-h dietary recall

Food group	Intake (g)		RDA* (g)	
	Man	Women	Man	Women
Cereal and millets	410±20.22	320±15.88	450	330
Pulses and legumes	64.9±19.6	39±12.85	90	75
Milk and milk products	125±18.99	100±21.63	300	300
GL vegetables	40.8±23.9	40±8.99	100	100
Other vegetables	120.6±53.4	88±13.57	200	200
Fruits	-	20±5.99	100	100
Sugar	20.2±8.9	25±3.98	30	30
Fats and oil	29±5.8	30±10.45	30	25

*RDA for moderate worker healthy adult men and women. Dietary guidelines for Indian - A Manual, NIN - ICMR, Hyderabad, 2011.
GL: Glycemic load, RDA: Recommended dietary allowance

The GI value of the test food (multigrain chapatti) resulting from the analyses was 45.61 ± 18.06 (i.e. 104g corresponding to 50g available carbohydrate), and the GL value was 4.88 per serving, i.e., 30 g, which is comparably less when compare to basic chapatti made with 100% wheat flour (i.e., 94.95 g of wheat flour corresponding to 50 g available carbohydrate) 61.41 ± 21.37 and GL for one serving, i.e.,30 g, 9.45 ± 2 [Table 4].

Baseline values in the two trials were compared by the paired *t*-test, a significant difference was found in the GI value of basic and multigrain chapatti. *P* values were considered statistically significant at $P < 0.05$. The results are presented as mean ± standard deviation apart from GI and GL.

Hence, it can be concluded that GI of basic chapatti was found to be comparable with that of published value[3] of same food, addition of multigrain flour mix to wheat flour improved the glycemic response of chapatti and resulted in comparably low GI and GL values.

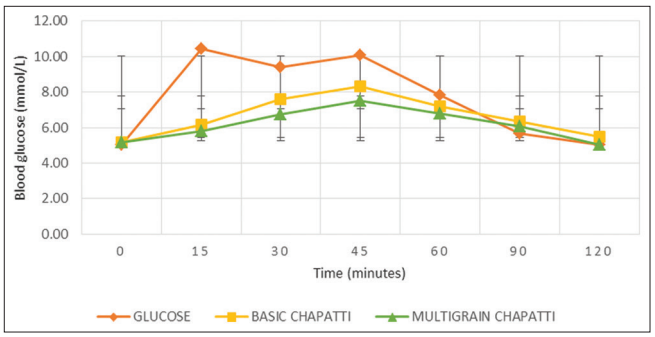

Figure 1: Mean change in glycemic response of glucose, basic and multigrain chapatti. *Standard deviation of mean values was represented as the vertical bar

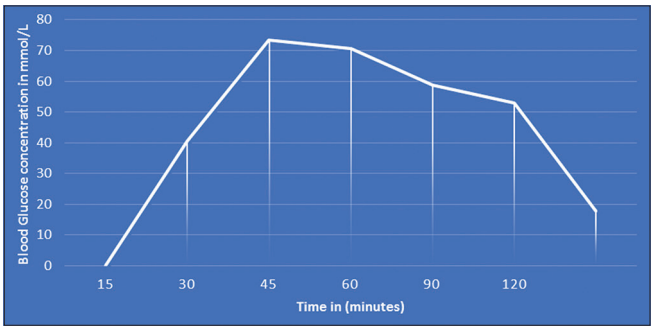

Figure 2: Mean incremental area under the curve of glucose

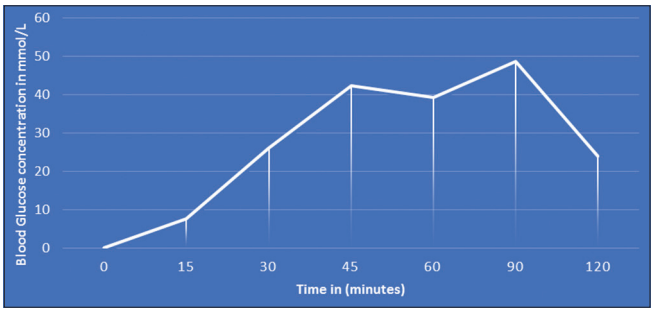

Figure 3: Mean incremental area under the curve of basic chapatti

Table 3: Mean change in glycemic response of glucose, basic and multigrain chapatti (mmol/L) measured at specific time points (*n*=17)

Testing food	15 min	30 min	45 min	60 min	90 min	120 min
Glucose	10.44±1.55	9.41±1.71	10.81±1.61	7.83±1.61	5.64±1.24	5±1
Basic chapatti	6.15±1	7.61±1.24	8.34±1.02	7.18±8.82	6.34±1.25	5.47±0.64
Multigrain chapatti	5.81±0.73	6.73±1.31	7.51±0.92	6.78±1.27	6.04±1.22	5.05±0.77

Table 4: Mean glycemic index and glycemic load value of basic and multigrain chapatti

Test food	*n*	Mean GI	Mean GL
Basic chapatti	17	61.41±21.37	4.88±3.39
Multigrain chapatti	17	45.61±18.06	9.45±2

GI: Glycemic index, GL: Glycemic load

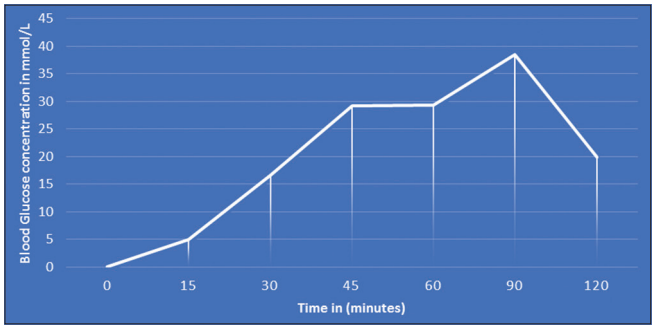

Figure 4: Mean incremental area under the curve of multigrain chapatti

Basic chapatti having 61.41 GI values can be classified as intermediate or moderate GI food, whereas multigrain chapatti with 45.61 GI values were considered as low-GI food. On the other hand, both these preparations having 4.88 and 9.45 GL can be categorized as food with low-GL profile.

CONCLUSION

This study concludes that the addition of high fiber and high protein ingredients can be incorporated in regular preparation without much altering sensory quality. It can be encouraged at the community level to develop such products to improve dietary adequacy. These results can be considered as the guidelines in the development of healthy nutrient-dense products for consumers keen to pick healthy alternatives to their diets.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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