

# Post-Prandial Responses to Different Bread Products Based on Wheat, Barley and Fenugreek or Ginger or Both in Healthy Volunteers and Their Effect on the Glycemic Index of Such Products

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**Abstract:** Background: Consumption of a diet with a low glycemic index (GI) rich in dietary fiber can help for the management of postprandial blood glucose (PBG) level in normal subjects. Incorporation of whole grain barley rich in  $\beta$ -glucan, fenugreek and ginger as part of a balanced diet offers a variety of health benefits. The purpose of the present work was to evaluate the effect of bread products containing wheat, barley and fenugreek or ginger or both on postprandial blood glucose in healthy subjects, and to determine their Glycemic index values. All bread products were evaluated for their acceptance value. Results: All bread products induced significantly lower PBG responses ( $p < 0.05$ ) than did the reference bread, suggesting that the naturally occurring soluble dietary fiber in these blends had an impact on glucose tolerance with glycemic indices ranging from 38 to 52. Conclusion: The present study suggests that barley wheat fenugreek ginger bread (BWFGb) could be a replacement food of white wheat bread since it provides a healthy and easily digestible carbohydrate diet that can help to maintain PBG level within a normal range in healthy and diabetic patients. [Journal of American Science. 2010;6(10):89-96]. (ISSN: 1545-1003).

**Key words:** Barley grain,  $\beta$ -glucan, fenugreek seeds, ginger seeds, glycemic response, glycemic index

## 1. Introduction

Functional food or medicinal food is any fresh or processed food which affects beneficially one or more target functions in the body, beyond adequate nutritional effects, in a way that is relevant to either improved state of health and well-being and/or reduction of risk of disease (Henson et al. 2008).

The development of food products that provide benefits beyond their traditional nutritional value has raised academic, industrial and public interest. In recent years, the ability of functional foods to impact metabolic parameters and eventually chronic diseases such as diabetes, obesity, cardiovascular disease and cancer has been deeply explored. Recent population studies have shown that the high Glycemic Index (GI) food is positively associated with the risk of developing type 2 diabetes (Barclay and Lie 2007, Villegas et al. 2007) and coronary heart disease (Ames and Rhymer 2008, Mente et al. 2009). Low-GI foods might play a role, and therefore could be defined as functional foods, in reducing the risk of such chronic diseases.

However, most of the conventional cereal products eaten at breakfast or as a snack have medium/high GI, ranging from 60 to 120 (bread as reference) (Foster-Powell et al. 2002). Viscous fibers have been shown to reduce post-prandial glycemia and insulinemia (Jenkins et al. 2000, Würsch and Pi-

Sunyer 2002) and have also been recognized since the 1960s as having lipid-lowering effects. Because barley grain has a high concentration of soluble fiber, and especially of  $\beta$ -glucan, there is an emerging interest in barley as a functional food ingredient (Newman and Newman 1991, McIntosh et al. 1995). Indeed this has promoted interest in high-  $\beta$ -glucan cultivars and in technological processing to concentrate these components in barley flour.

Barley (*Hordeum vulgare vulgare* L.) is an ancient cereal grain, which upon domestication has evolved from largely a food grain to a feed and malting grain. However, barley food use today, remains important in some cultures around the world, particularly in Asia and northern Africa, and there is renewed interest throughout the world in barley food because of its nutritional value. Renewed interest in barley for food uses largely centres around the effects of  $\beta$ -glucans on lowering blood cholesterol levels and glycemic index. Wholegrain barley foods also appear to be associated with increased satiety and weight loss. There is a great potential to utilise barley in a large number of cereal-based food products as a substitute partially or wholly for currently used cereal grains such as wheat (*Triticum aestivum*), oat (*Avena sativa*), rice (*Oryza sativa*), and maize (*Zea mays*) (Baik and Ullrich 2008).

Diet has been recognized as a corner stone in the management of diabetes mellitus. Spices

are the common dietary adjuncts that contribute to the taste and flavour of foods. Besides, spices are also known to exert several beneficial physiological effects including the antidiabetic influence. Among the spices, fenugreek seeds (*Trigonella foenum-graecum*) and ginger (*Zingiber officinale*) have been reported to be hypoglycaemic (Srinivasan 2005).

Ginger root is commonly used as a spice in food and beverages and as a traditional medicine, especially in South Asia. It is used as a fresh root, root extract or powder form. Chemical components in ginger root include 6-Gingerol, 8-gingerol, 6-shogaol and 10-gingerol. The gingerols and other compounds (flavonoids) in ginger root extract have been shown to have antioxidant activity (Zhang 2009). Altogether about 50 types of antioxidants are identified in extract of ginger root.

Recently, different medical studies have been conducted focusing on ginger and its health benefits. The numerous health benefits obtained from ginger consumption include the treatment of nausea and vomiting (Chaiyakunapruk et al.2006), as well as for arthritis (Altman and Marcussen 2001). Ginger is insulinotropic rather than hypoglycemic (Islam and Choi 2008).

Fenugreek (*Trigonella foenum-graecum*), a member of the Leguminosae family has been used as a cooking spice and flavoring agent for centuries (Jellin et al.1999). The plant grows in India, Egypt, and the Middle East. Fenugreek is a legume rich in protein, fiber and omega 3 fatty acids (McWhorter 2001). Fenugreek seeds and its extract have exhibited hypoglycemic and hypocholesterolemic activity in animal and human models. Inclusion of fenugreek in the daily diet in amount of 25-100g can serve as an effective therapy in the clinical management of diabetes (Gopalpura et al. 2007).

The purpose of this study was to evaluate glucose responses in healthy subjects using five different bread products obtained from barley and wheat flour to which fenugreek, ginger, or both were added in different proportions, in comparison with white wheat bread as a reference and to calculate their Glycemic Index. All tested bread were also analyzed for their acceptability values.

## 2. Material and Methods

Freshly milled wheat flour (extraction 72%), Fenugreek and Ginger flour were all purchased from local market. Raw Barley kernels with hulls (*Hordeum vulgare*), variety "Giza 126" were provided by the Ministry of Agriculture. Seeds were obtained just after the harvesting time, washed with running tap water, air dried and made into fine particles in a mill grinder.

### Preparation of Blends

1- WWb made from 100% refined wheat flour, and used as reference food.

2-BWb (Basic recipe) made from 50% Barley flour (BF) + 50% refined wheat flour (RWF).

3- BWFB-5 made from 95% basic recipe + Fenugreek flour (FF 5%).

4-BWFB-2.5 made from 97.5% basic recipe + Fenugreek flour (FF 2.5%).

5-BWGb-2.5 made from 97.5% basic recipe + Ginger flour (GF 2.5%).

6-BWFGb made from 98% basic recipe + Fenugreek flour (FF 1%) + Ginger flour (GF 1%). All blends were well mixed and sieved through a 60- mesh sieve for uniform mixing as shown in table(1).

For development of dough, five g. salt, 2.5 g. yeast, 6 g. sugar and necessary warm water were added to all blends.

Each dough was proofed for 60 minutes to allow fermentation, flattened and cut into round pieces of 15 cm diameter and 0.3 cm thickness, subjected to a second proofing for 30 minutes. Wheat bread was baked in an oven at 250° C, while the other types of bread were baked at 400-450°C for 6 minutes.

Bread prepared was left to cool for 15 minutes, then packaged in polyethylene bags, sealed and stored in refrigerator at 4° C for 1 to 5 days.

### *Determination of the acceptance values of different bread products*

Prepared and reference bread were given to Twenty healthy volunteers for evaluating the acceptance value according to the British nutrition foundation (2006). The volunteers assessed the bread for seven attributes on a scale of 0-5 table (3).

### Subjects

Twenty healthy non smoking volunteers (12 men and 8 women) were chosen for determination of glycemic index. They were of  $40 \pm 5$  years old, with normal Body Mass Indices ( $21.5 \pm 0.6$  in  $\text{kg/m}^2$ ) and without drug therapy participated in the study. The study was performed over a period of two months and all subjects were aware of the possibility of withdrawing from the study at any time.

### *Determination of Glycemic Index (GI)*

The Glycemic index (GI) of different bread products was determined by feeding the volunteers. They were served, the calculated portions of the tested bread containing 50 grams of carbohydrate as breakfast test bread after an overnight fast (10 hours) in a random order as recommended by the FAO/WHO (1998). Portion sizes were 100g for white

bread (reference food), 119g for different types of tested barley bread. The tests were started at the same time in the morning (between 8.00 and 8.30 a.m.). All tested bread were consumed steadily over a 10-12 min period. Volunteers were allowed to drink only water with the tested bread. White wheat bread was chosen as the reference food.

#### Blood glucose estimation

Blood samples obtained through an intravenous catheter inserted into a forearm vein. Fasting and postprandial blood glucose responses were determined at time periods of 0, 30, 60, 90 & 120 min after the ingestion of carbohydrates with a glucose oxidase peroxidase reagent using stanbio kit (USA). The glucose area under curve (AUC) for each subject and tested bread was calculated, and that for the reference food (white bread) was also measured ignoring any area beneath the baseline. Glycemic index for the tested bread was then calculated by dividing the value of glucose AUC for the test food by that for the reference food multiplied by 100 (Wolever et al. 2006) as shown in the following equation:

$$\text{Glycemic index} = \frac{\text{AUC of food}}{\text{AUC of reference food}} \times 100$$

#### Statistical analysis

Results are expressed as means  $\pm$  SEM. Data were analyzed by one-way ANOVA. Comparison of each pair of means was carried out using Tukey's Honestly Significant Difference (HSD) using SPSS/PC statistics program version 8.0 according to the technique described by Daniel (1991) and Bailey (1984). A value of  $p < 0.05$  was considered significant.

### 3. Results

Acceptance values of all bread products are shown in table 3. The acceptance value of BWb ( $3.9 \pm 0.44$ ) was significantly higher ( $p < 0.05$ ) than that of BWfb-2.5 ( $3.1 \pm 0.24$ ), BWGb-2.5 ( $3.06 \pm 0.22$ ), BWFGb ( $2.6 \pm 0.30$ ), and BWfb-5 ( $2.7 \pm 0.22$ ) respectively. Barley wheat bread (BWb) was found to

be the most acceptable of the five barley bread products.

The calculated nutritional values of all bread products are reported in table 2. Subjects fasting blood glucose level were in the normal range and did not differ among barley tested products or white wheat bread reference.

#### Postprandial blood glucose responses

All barley tested products resulted in a significantly lower blood glucose increments ( $p < 0.05$ ) than did the white wheat reference bread at any time point as shown in table 4. In addition, in the early phase (30 min), the glucose response to the Barley wheat fenugreek bread (BWfb-2.5), Barley wheat ginger bread (BWGb-2.5) and Barley wheat fenugreek bread (BWfb-5) did not significantly deviate from that to the barley wheat bread, while a significant decrease ( $p < 0.05$ ) was observed with the Barley wheat fenugreek ginger bread, compared with barley wheat bread. In the late postprandial phase (90-120 min), the glucose response of all barley tested products (mixed with either fenugreek or ginger) did not significantly deviate from that to the barley wheat bread (BWb). At the 60 min phase, the glucose response to the Barley wheat ginger bread (BWGb-2.5) and Barley wheat fenugreek bread (BWfb-5) significantly deviate from that to the barley wheat bread (BWb).

The AUC and GI values of healthy subjects after consumption of white wheat reference bread, and different barley bread products are shown in table 5. The AUC for BWb ( $1550 \pm 109$ ), BWFGb ( $975 \pm 96$ ), BWfb-2.5 ( $1350 \pm 111$ ), BWfb-5 ( $1140 \pm 78$ ) and BWGb-2.5 ( $1365 \pm 93$ ) were significantly lower ( $p < 0.05$ ) than that of the white wheat bread reference ( $2985 \pm 189$ ). Similarly, lower glycemic indices ( $p < 0.05$ ) were noted with all barley products compared with white wheat reference bread. In contrast, the GI of Barley wheat fenugreek bread (BWfb-2.5) or Barley wheat ginger bread (BWGb-2.5) and the BWb could not be distinguished and showed no significance. Meanwhile, the GI of BWFGb or BWfb-5 were significantly lower ( $p < 0.05$ ) than that of BWb.

**Table 1. Ingredients used for baking bread products g/kg**

Ingredient	WWb	BWb (Basic recipe)	BWfb-5	BWfb-2.5	BWGb-2.5	BWFGb
RWF	1000	500	475	487.5	487.5	490
BF	-	500	475	487.5	487.5	490
FF	-	-	50	25	-	10
GF	-	-	-	-	25	10
Total	1000	1000	1000	1000	1000	1000

RWF: Refined wheat flour

FF: Fenugreek flour

BF: Barley flour

GF: Ginger flour

**Table 2. Nutritional values of bread products (g/100g edible portion)**

Bread	Moisture	Protein	Fat	Fiber	Ash	Carbohydrates*	Energy (K cal)
WWb	38	8.03	3.53	2.25	1.86	46.33	321.34
BWb	24	8.9	1.53	5.54	0.76	59.27	326.3
BWFb-5	23.16	9.39	1.71	6.25	0.86	58.63	327.48
BWFb-2.5	23.58	9.15	1.62	5.89	0.81	58.95	326.43
BWGb-2.5	23.59	8.87	1.61	5.66	0.83	59.44	326.39
BWFGb	23.67	9.00	1.6	5.68	0.81	59.24	326.62

\* Calculated by difference

**Table 3. Acceptance evaluation of bread products**

Attributes	BWb	BWFb-5	BWFb-2.5	BWGb-2.5	BWFGb	Standard food
Liking of color	3.4 ± 1.7	2.0 ± 0.26	2.5 ± 0.23	2.9 ± 0.3	2.6 ± 0.10	4.0 ± 0.30
Breakability	3.7 ± 0.20	2.7 ± 0.15	3.0 ± 0.18	3.3 ± 0.10	3.1 ± 0.37	4.2 ± 0.37
Chewability	3.9 ± 0.28	2.2 ± 0.12	2.4 ± 0.21	3.0 ± 0.12	2.6 ± 0.14	4.5 ± 0.26
Taste	4.2 ± 0.15	2.4 ± 0.32	2.6 ± 0.11	2.7 ± 0.16	1.9 ± 0.24	4.5 ± 0.12
Sense of satiety	4.1 ± 0.27	4.9 ± 0.41	4.6 ± 0.38	4.4 ± 0.25	4.2 ± 0.33	3.8 ± 0.54
Aftertaste	3.5 ± 0.22	2.4 ± 0.17	2.7 ± 0.35	1.7 ± 0.34	2.1 ± 0.25	4.0 ± 0.40
Over all liking	4.4 ± 0.28	2.2 ± 0.14	3.8 ± 0.21	3.4 ± 0.29	2.0 ± 0.66	4.7 ± 0.13
Mean ± SD	3.9±0.44 <sup>a</sup>	2.7±0.22 <sup>b</sup>	3.1±0.24 <sup>c</sup>	3.06±0.22 <sup>d</sup>	2.6±0.30	4.2±0.30

n = 20, Data of bread products were subjected to one way analysis of variance by Tukey multiple comparison test. Means within a row containing different superscript are significantly different (P < 0.05).

**Table 4. Blood glucose concentration of healthy subjects after consuming bread products<sup>1</sup>.**

Groups	Blood glucose concentration (mg/dl)				
	0 min	30 min	60 min	90 min	120 min
White wheat bread (WWb)	78±3.2 <sup>a</sup>	124±5.7 <sup>a</sup>	117±3.4 <sup>a</sup>	100±6.1 <sup>a</sup>	86±7.2 <sup>a</sup>
Barley wheat bread (BWb)	77±2.6 <sup>a</sup>	105±3.1 <sup>b</sup>	82±2.4 <sup>b</sup>	72±4.3 <sup>b</sup>	78±2.9 <sup>b</sup>
Barley wheat fenugreek bread (BWFb-5)	80±2.5 <sup>a</sup>	97±3.8 <sup>bc</sup>	93±3.3 <sup>bc</sup>	82±3.2 <sup>b</sup>	73±2.2 <sup>b</sup>
Barley wheat fenugreek bread (BWFb-2.5)	83±3.7 <sup>a</sup>	100±4.3 <sup>b</sup>	85±3.5 <sup>b</sup>	72±3.7 <sup>b</sup>	77±3.3 <sup>b</sup>
Barley wheat ginger bread (BWGb-2.5)	83±4.1 <sup>a</sup>	102±2.8 <sup>b</sup>	99±2.1 <sup>c</sup>	81±2.5 <sup>b</sup>	70±2.7 <sup>b</sup>
Barley wheat fenugreek ginger bread (BWFGb)	74±2.8 <sup>a</sup>	90±4.8 <sup>c</sup>	77±2.7 <sup>b</sup>	74±2.4 <sup>b</sup>	70±2.4 <sup>b</sup>

<sup>1</sup>Means±SEM, n = 20. Means within a column containing different superscript are significantly different (P < 0.05).

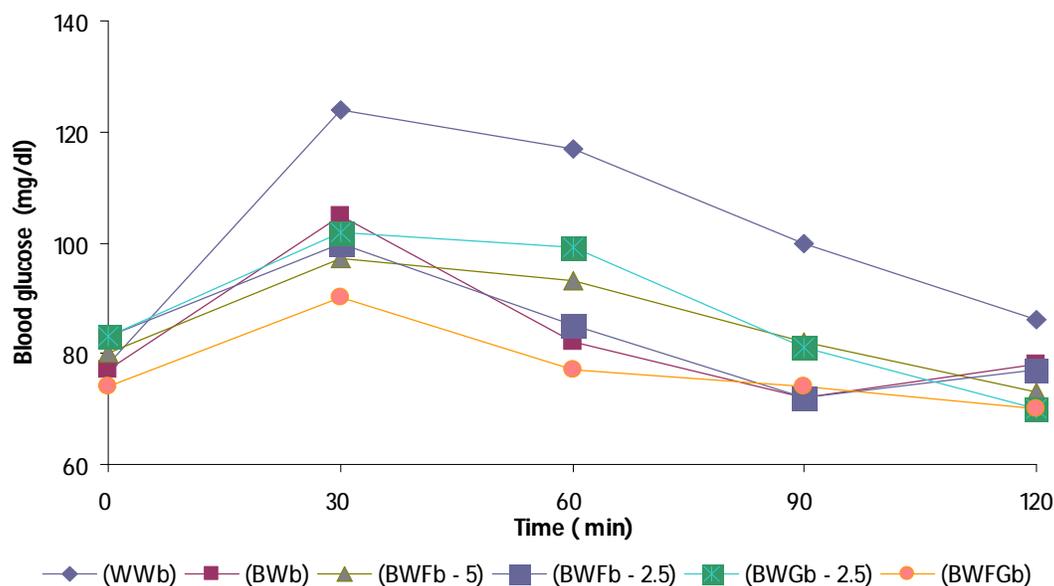
**Table 5. Glucose AUC, Glycemic index of experimental bread products<sup>1</sup>**

Product	*Glucose AUC	*Glycemic Indices
White wheat bread (WWb)	2985±189 <sup>a</sup>	72 ± 14.4 <sup>a</sup>
Barley wheat bread (BWb)	1550±109 <sup>b</sup>	52±12.1 <sup>b</sup>
Barley wheat fenugreek bread (BWFb-5)	1140±78 <sup>c</sup>	38±7.9 <sup>c</sup>
Barley wheat fenugreek bread (BWFb-2.5)	1350±111 <sup>b</sup>	45±9.6 <sup>b</sup>
Barley wheat ginger bread (BWGb-2.5)	1365±93 <sup>b</sup>	46±8.3 <sup>b</sup>
Barley wheat fenugreek ginger bread (BWFGb)	975±96 <sup>c</sup>	33±13.4 <sup>c</sup>

<sup>1</sup> Means ±SEM (n=20).

\* evaluated at 120 min.

Values with different superscript letters are significantly different for p<0.05(Tukey HSD post-hoc test).



**Figure 1: Blood glucose concentrations in healthy subjects following ingestion of white wheat bread and bread products. Values are means, (n=20). Error terms and results of statistical analyses are given in Table 4. Abbreviations used: WWb, white wheat bread ; BWb; barley wheat bread, BWFGb; barley wheat fenugreek ginger bread, BWGb-2.5; barley wheat ginger bread, BWFb-2.5; barley wheat fenugreek bread, BWFb-5; barley wheat fenugreek bread.**

#### 4. Discussion:

In the present study, the postprandial responses of healthy subjects to bread made from wheat flour or wheat flour plus either barley flour, barley flour to which fenugreek, ginger or both were added in different proportions were determined.

Results showed that different types of tested barley bread induced a significantly lower postprandial rise in glucose response in healthy subjects when compared to the reference food (fig.1) resulting in significantly ( $p < 0.05$ ) lower Glycemic indices for all barley bread. Thus, the naturally occurring dietary fiber in barley flour may have an impact on glucose tolerance. Barley is high in soluble viscous fiber and the consumption of products such as pasta, bread and porridge enriched with barley  $\beta$ -glucan has been repeatedly shown in literature to blunt glycemic and insulinemic responses (Liljeberg et al. 1996, Cavallero et al. 2002). The extent of reduction has been investigated by Jenkins et al. (2002) who demonstrated that each gram of  $\beta$ -glucan can be expected to lower the GI by 4 GI units making it a useful dietary supplement or functional food ingredient for reducing postprandial glycemia (Casiraghi et al.2006).

Battilana et al. (2001) suggested that the lowered post-prandial glucose concentrations which are observed after a barley meal containing  $\beta$ -glucan are essentially due to delayed and somewhat reduced carbohydrate absorption from the gut. This effect is related to the impairment in transit and absorption due to meal viscosity which is suggested by the studies of Wood et al. (2000) who has shown a highly significant linear inverse relationship between log [viscosity] of  $\beta$ -glucan mixtures and the glucose and insulin responses in healthy subjects. The relationship showed that 79–96% of the changes in plasma glucose and insulin was attributable to viscosity. The soluble fiber in barley whole grains may help increase satiety by delaying gastric emptying and slowing nutrient absorption in the small intestine which may reduce glucose and insulin responses and risk of obesity (Juvonen et al.2009).

FDA approved health claim for barley-based food that contain beta-glucan soluble fiber and met other claim criteria (Docket No.2004P-0512). Barley has a distinct advantage over some other grains in that beta-glucan soluble fiber is found throughout the entire barley kernel. In some other grains, the fiber is only found in the outer bran layer. If these grains are processed, the fiber can be easily lost. This is not the case with barley. Since fiber is found throughout

barley kernel, even refined products such as barley flour contain beta-glucan soluble fiber making the grain a healthy ingredient for commercial food applications.

Barley, as a whole grain or as an extract can provide a useful addition to menus to control plasma glucose responses. It can serve as a fat replacer in food products since its content of  $\beta$ -glucan is highly viscous in nature and has a water binding capability (Biliaderis and Izydorczyk 2006).

In our present study, the most prominent lowering of glycemic response was obtained with the barley wheat fenugreek ginger bread (BWf gb) which displayed very low GI (33). After a meal, blood glucose levels rise as glucose is absorbed from the intestine. The body then produces insulin, to clear glucose from the blood and transport it to tissues and organs where it is used. As blood glucose levels drop again, insulin production is switched off. This rise and subsequent fall in blood glucose levels after a carbohydrate meal is called the *glycemic response*. When barley is incorporated in bread formulations, the glycemic response is moderated as glucose is more slowly absorbed into the blood. Sudden high peaks of glucose and insulin are avoided and glucose energy is available in the blood over a sustained period of time (Behall et al.2006).

The lowering of glycemic response to the BWf gb may be also due to the gel forming characters of fenugreek fiber which reduces gastric emptying, glucose absorption and the insulin response (Ylonen et. al 2003 and Gopalpura et.al 2007). Fenugreek has the potential to speed the process of glucose being used for energy, thereby preventing unhealthy levels to circulate in the blood. By this action it can help to break the vicious cycle of impaired carbohydrate metabolism, which promotes insulin resistance and weight gain.

Recent studies attribute its hypoglycemic effects to the amino acid 4-hydroxyisoleucine which may have effects on pancreatic beta cells by retarding glucose absorption and thus reduces serum insulin levels (Gopalan et al. 1998 and Krishnaswamy 2008). Various components of the fenugreek seeds have varying activities. For example, the component called fenugreekine, a steroidal saponin peptide ester, may have hypoglycemic properties (Jellin et al.1999). Trigonelline, another component, may exert hypoglycemic effects in healthy patients without diabetes, but other studies have shown that fenugreek has no effect on fasting or postprandial blood glucose levels in nondiabetic subjects (Bordia et al. 1997).

It has been suggested that ginger is insulinotropic through stimulating or affecting the production and activity of insulin rather than hypoglycemic (Islam and Choi 2008). Ojewole

(2006) found that *Zingiber officinale* rhizomes ethanol extract possesses hypoglycaemic properties; by enhancing the insulin-sensitivity, thus ginger may be used in the management and/or control of type 2 diabetes mellitus (Sekiya et al.2008). Gingerol, the pungent principle in ginger, saponin and fiber present in fenugreek are immensely valuable in health care with their multiple physiological effects (Shylaja and Peter 2007). An additional benefit of all barley bread products by maintaining normal blood sugar levels is reduction of food cravings.

## 5. Conclusion

All types of tested barley bread based on 50% barley flour attenuated a low glycemic index. These findings clearly show that inclusion of barley grains tested in the present work offers new ways of reducing the high GI seen with conventional cereal products. Thus increasing the intake of whole grain products such as barley would increase both total and soluble dietary fiber in the diet and most likely would result in retarding the glucose release. Such products may have a potential use in the dietary management of type 2 diabetes. Spices such as fenugreek and ginger have synergistic actions and are likely to protect the human body against diabetes.

Therefore, consumption of the low GI barley wheat fenugreek ginger bread could be a replacement food of white wheat bread, since it provides a healthy and easily digested carbohydrate diet that can help to maintain postprandial blood glucose within a normal range in healthy subjects, suggesting its use as a potential component of diets for patients with diabetes and hyperlipidemia, and for individuals predisposed to metabolic disease.

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