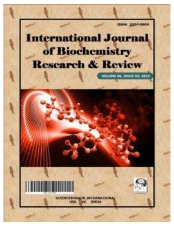

International Journal of Biochemistry Research & Review

18(4): 1-10, 2017; Article no.IJBCRR.34471
ISSN: 2231-086X, NLM ID: 101654445

Glycemic Index of Some Traditional Ethiopian Foods

Meaza Assefa[1*], Melaku Umeta[1] and Natesan Gnanaseknran[1]

[1]Department of Medical Biochemistry, School of Medicine, College of Health Sciences, Addis Ababa University, Ethiopia.

Authors' contributions

This work was carried out in collaboration between all authors. Author MA designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors MU and NG managed the analyses of the study and the literature searches. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJBCRR/2017/34471
Editor(s):
(1) Mohamed Fawzy Ramadan Hassanien, Biochemistry Department,Faculty of Agriculture,Zagazig University, Egypt.
Reviewers:
(1) Ilias Migdalis, NIMTS Hospital, Greece.
(2) Hala Mohamed Salah El-Din Moustafa Megahed, National Research Centre, Egypt.
Complete Peer review History: http://www.sciencedomain.org/review-history/20922

Original Research Article

Received 29th May 2017
Accepted 28th June 2017
Published 11th September 2017

ABSTRACT

Background: Glycemic index (GI) describes the blood glucose response after consumption of a carbohydrate containing test food relative to a reference food, typically glucose or white bread. Glycemic index was originally designed for people with diabetes as a guide to food selection, advice being given to select foods with a low GI. In Ethiopia information with regard to the glycemic index of commonly consumed traditional foods are not known. Therefore, the current study aims atassessingthe glycemic index of some common traditional Ethiopian foods. Thus generating information for the dietary management of diabetes mellitus.

Materials and Methods: Twelve different traditional Ethiopian foods were randomly selected from the local market and prepared at home following traditional methods. The foods were dried with sun light and oven (<85°C) and then the dried foods were manually grinded and powdered. The powders were kept in clean glasses at room temperature until used for the experiment. Twelve healthy mice (six for control and six for the test group) for each tested foods were used for the study. The mice were divided into two groups, group 1 is standard (each mouse administered 0.25 g of glucose) and group 2 is test (each mouse administered 0.25 g of test food). The test food and standard glucose were administered after overnight fasting and the blood glucose were measured at 30 minute intervals for the next twohours (0, 30, 60, 90 and 120 minutes). The blood glucose response curve

**Corresponding author Meaza Assefa: Email: Meazassefa@gmail.com;*

was used to calculate the incremental area under the curve (IAUC) of each food and glucose. Glycemic index of food was calculated as a percentage of incremental area under the curve (IAUC) of each food from standard glucose and expressed as Mean±SE of each food.

Results: The result indicated thatamong the twelve traditional Ethiopian foods eight were found to have low glycemic index (GI≤55); these include: 1. White teff *enjera*, GI=35, 2. Red teff *enjera*, GI=39, 3. Maize *enjera*, GI= 43, 4. Barley bread, GI=25, 5. Qocho bread, GI=38, 6. pea sauce, GI=41, 7. Chickpeas sauce, GI=27, 8. Lentil sauce, GI=17, three foods had a moderate glycemic index (GI=56-69):1. Maize bread, GI= 56, 2. wheat bread, GI= 57, 3. Bulla*genfo*, GI=60 and one had a high glycemic index (GI≥70): 1. White bread, GI= 73.

Conclusions: The examined traditional Ethiopian foods provided important information for the public to guide food choice and could be useful for the prevention of diabetes mellitus.

Keywords: Glycemic index; carbohydrate; blood glucose response; glucose and test foods.

1. INTRODUCTION

The glycemic index (GI) is a concept that ranks the glycemic potency of foods. GI is an empirical system for classifying carbohydrate-based foods, founded on the degree of glucose release into the blood stream once ingested [1]. Foods with a high GI break down rapidly, are absorbed and cause a rise of the blood glucose quickly in the body. The low GI foods have slower break down, absorption and cause a slower rise of the blood glucose level. The concept of GI is based on both chemical composition and physiological properties of carbohydrates containing foods [2].

Glycemic index ranks foods on a scale from 0 to 100. All carbohydrate-containing foods are categorized under high, moderate, and low depending on the numerical value derived from foods. Individual foods with low glycemic index (GI≤55) release glucose more slowly over several hours. Moderate index foods are between 56 and 69. Foods with high glycemic index are greater than 70 (GI≥70). The GI concept has been developed to obtain a numerical physiological classification of carbohydrate containing foods and meals based on the rate of carbohydrate absorption into the blood, to improve nutritional advice [3]. Carbohydrate foods are important for providing the steady fuel supply. Monitoring energy and blood glucose levels is especially important for athletes and people with health implications, such as diabetes mellitus. Due to the importance of balancing blood glucose levels in diabetics, low to moderate glycemic foods are important to control blood glucose in these individuals [4].

For athletes' carbohydrate-loading (CHO-loading) regimens prior to endurance exercise, total carbohydrate is a much more important consideration than the GI of the foods/diets chosen. For the food prior to endurance exercise, there appears to be competitive advantage to selecting low-to-moderate GI foods, because low GI foods caused higher fat oxidation rates [5]. Increasing fat oxidation spares CHO thus making the fuel supply last longer. In addition, ingestion of low to moderate GI foods increased the availability of non-essential fatty acids during exercise and decreased the reliance on intramuscular lipid during moderate intensity exercise [6]. There was also a slight but limited advantage of a higher GI diet or food for replenishing glucose by restore muscle glycogen after exercise [7,8]. However, since foods naturally low in GI are often rich in fiber and other nutrients that are important to avoid the risk factors for developing diabetes -such as insulin resistance and obesity- by enhancing insulin sensitivity and controlling body weight by decreasing fat storage, so the GI of the food or diet may simply flag a dietary choice that helps to reduce risk of type 2 diabetes (T2DM). This concluded that due to the importance of balancing blood glucose levels in diabetes, low to moderate glycemic foods are important to moderate blood glucose in these individuals [9].

The glycemic index (GI), first proposed in 1981, is a system of classifying food items by glycemic response. Over the past 35 years, low-GI diets have been associated with decreased risk of cardiovascular disease, type 2 diabetes, metabolic syndrome, stroke, depression, chronic kidney disease, formation of gall stones, neural tube defects, formation of uterine fibroids, and cancers of the breast, colon, prostate, and pancreas. Taking advantage of these potential health benefits can be as simple as sticking with whole, natural foods that are either low or very low in their GI value. The study is important for diabetes, metabolic syndromeand weight management.

To bring literature surveys showing that there is little or no knowledge about the glycemic index of traditional Ethiopian foods. Therefore, the aim of this study was to explore the pattern of glycemic index of commonly consumed traditional Ethiopian foods, so that it may generate some useful information for health professionals during the management of certain disease such as diabetes mellitus.

2. MATERIALS AND METHODS

2.1 Test Foods

Twelve different traditional Ethiopian foods were randomly selected from the local market and the traditional way of preparing these foods were done at home. These include;

2.1.1 Cereal based foods

Enjera

Teff, *Eragrostis tef (Zucc.) Trott*.:, white enjera & red/brown enjera, and
Maize (Corn), *Zea mays L*. enjera.

Breads

Barley, *Hordeumvulgare L*.: bread,
Wheat, *TriticumvulgareVill.:,* bread (traditional *diffodabo*),
Maize (Corn), *Zea mays L*.:,bread (traditional *diffodabo*)*,* and
White bread (bread from bakery)
Ingredient-; Wheat flour, oil, commercial yeast, salt and water

2.1.2 Root and root based products

False banana, *Ensete ventricosum*.:, Bullagenfo and Qoch'o bread.

2.1.3 Legume based food products

Pea, *Pisum sativum L*.:, Sauce (*AterShiro wet*),
Chickpea, *Cicer arietinum L*.:, Sauce (*Shimbra Shiro wet*), and
Lentil (split), *Lens culinaris Med*.: Sauce (*Missir wet*).

2.2 Processing of Raw Materials

2.2.1 Preparation of cereals

All cereals collected from local market were cleaned and milled in local mills. But white breads were collected from the local bakery.

2.2.2 Preparation of enjera (Teff white and red/brown enjera), and Maize (Corn) enjera

Measurement and ingredients-; Teff flour, warm water, Maize flour, large bowl and pan.

Preparation method; the teff or maize flour and water mixed withstarter culture (a batter from a previous fermentation (Ersho). The mixture was kneaded for 5-10 minutes. The dough was left to ferment for 2 days at room temperature. The yellowish liquid at the top of the dough was discarded after 2 days fermentation. After the liquid is discarded some amount of the dough was boiled (locally known as 'absit'). After the absit was cooled it was mixed with the rest of the dough. Then it was left to ferment once again and it took at least 1hr to rise, at room temperature until foam and bubbles were formed. Pour about 500 ml of the batter in a circular manner on 50 cm diameter hot clay griddle "*mitad"* and bake covered for about 2minutes. Removed enjera by lifting it off the hot griddle and sliding over a straw mat.

2.2.3 Preparation of breads:- [Wheat, Barley, and Maize (Corn) breads]

Measurement and ingredients-; cups of wheat, barley/ maize flour, sugar, commercial yeast, salt, bowl, oil, water and pan.

Preparation method; combined cups of flour, salt, yeast, and oil in a large mixing bowl. Stir to blend. In a saucepan, heat the sugar and water. Pour into dry ingredients and mixed for 2 minutes. Stir in enough of the remaining flour to makesoft dough. Transfer dough to a lightly floured surface and kneaded until smooth and elastic. Shape into a ball and placed in a greased bowl. Covered loosely with a towel and let rise until double. Then the dough was kneaded to get rid of the big bubbles and made it uniform. It was placed in loaf pan and allowed to rise again for another hour until it fills the loaf pan. It was baked in an oven preheated to 150-175°C for about 45 minutes until golden brown. Removed from pans and finally to get bread.

2.2.4 Preparation of legumes

All legumes collected from the local market were cleaned and milled in local mills.

2.2.5 Preparation ofpea and chickpea sauce

Measurement and ingredients -; pea/ chickpeas powder, onion, cup of vegetable oil, garlic, *berbere*, salt and water.

Preparation method; Placed the onion and garlic in a food processor or in medium pot. Added a little water and heat the oil, saucepan over medium flame. Then *berbere* and simmer added for about few minutes at low heat and put in a dash of water to avoid sticking, until the excess moisture evaporates and the onion loses its raw aroma, about 5-10 minutes. Add the water and mixed the *shiro* by adding a small portion of *shiro* flour at a time and continuously stirring. Enough amount of salt added and let it cooked until it became thick, but runny for about 30-40 minutes at low heat. Finally to get pea/ chickpea sauce.

2.2.6 Preparation of lentil sauce (*Missir wet)*

Measurement and ingredients -; Split red lentil, onions, vegetable oil, garlic, *berbere*, salt and water.

Preparation method; Placed the onion and garlic in a food processor or in medium pot. Added a little water and heat the oil, saucepan over medium flame. Then *berbere* and simmer added for about few minutes at low heat and adding a dash of water to avoid sticking, until the excess moisture evaporates and the onion loses its raw aroma, about 5-10 minutes. Add the water and mixed lentils to the saucepan. Enough amount of salt added and let it cooked and simmer until lentils are cooked through and fall apart, about 40 to 55 minutes at low heat. Added the water to keep the lentils from drying out. Finally to get lentil sauce.

2.2.7 Preparation of root and root product (qocho bread and bulla *genfo*)

All root and root based products collected from local market were manually scraping and squeezing. Preparation method of qocho bread-; Qocho powder was mixed with water. The mixture was kneaded for 5-10 minutes. This dough was formed into flatbreads by wrapping it in a thin layer of ensete leaves and this dough was packedon a griddle (*mitad*). Preparation method of bulla *genfo*-; to prepare bulla *genfo* added enough amount of bulla flour to cup of boiling water in a medium pan. Stir it all up and when it was smooth, added a little salt and let it cooked, about 15 to 25 minutes at medium heat. Removed from the pan, finally to get bulla *genfo*.

2.3 Inclusion Criteria

Gender: Male and female mice.

Part of the study: healthy mice [Fasting blood glucose value (at time 0) between 70-126 mg/dl].

Mice that were used for GI tests should be studied in the morning at breakfast time, after an overnight fast of 10–14 hrs on separate days.

When to calculating IAUC, if blood glucose value fell below the baseline, only the area above the fasting level was included.

2.4 Exclusion Criteria

Diagnosis of diabetes mellitus (DM).

Use of medications or nutritional supplements known to affect glucose metabolism.

For the purpose of statistical evaluation all tests that were not complete and all tests where the first (i.e. fasting) blood-glucose concentration was 126 mg/dl or higher were excluded.

2.5 Experimental Design

2.5.1 Experimental animals

Adult male Swiss albino mice aged between 12 and 14 weeks were used for the study. Mice were purchased from Ethiopian Health and Nutrition Research Institute (EHNRI). All the mice were acclimatized to the laboratory condition for one week before commencing the experiments and fed with pellet and free access of water. The animals were housed in 12 hours light and dark cycle at room temperature. The experiment was performed in the laboratory of Pharmacology Department, School of Medicine, Addis Ababa University after ethical approval protocol number 0022/2013. All animal handling and care was done as per the guidelines set by the national academies press, Washington, D.C., USA.

2.5.2 Experimental protocol

Swiss albino mice were divided into two groups of six animals each.

Group 1: This group was kept as control and animals administered with standard glucose (0.25 g).

Group 2: This group was a test and administered with test foods (0.25 g).

2.5.3 Proximate composition analysis

The moisture, total nitrogen, protein, fat, carbohydrate, crude fiber, ash, and mineral contents of test foods were analyzed according to AOAC methods. All samples were collected, prepared using traditional methods and stored in -20°C until analysis. Before analysis, samples were equilibrated to room temperature. Care has been taken for components in the food which can easily undergo chemical changes by exposure to air and light.

2.5.4 Making tested foods in to powder

After preparing the tested food with different methods, and then the foods were dried by sun light and oven (<85°C). The dried foods were manually grinded and the powders were kept in clean glasses at room temperature until used for the experiment/test.

2.5.5 Preparation of food powder solution for administration

The powder food (0.25 g) was weight dissolved in 1 ml of water administered into each mouse (six). The same way the standard (glucose) 0.25g was weighed, dissolved in 1ml of water to administer each mouse (six).

2.5.6 Estimation of blood glucose concentrations using glucometer

Fasting blood glucose was measured with GlucoSure® Plus glucometer after getting the blood sample from the tail vein of the overnight (12-14 hr) fasted mice and measured blood glucose after administered foods and standard glucose with 30 minute intervals for 2hrs (0, 30, 60, 90, 120 min).

2.5.7 Blood glucose response graphs

The blood glucose response curve vs. time was obtained by plotted a graph thus: x-axis, time interval and y-axis, blood glucose concentration. The averages of the respective blood glucose response before and after administering the food were used to draw a blood glucose response curve for the two-hour period.

2.5.8 Calculations of glycemic index

The incremental area under the curve (IAUC) was calculated for each food in every mouse separately (as the sum of the surface of triangles and trapezoids between the blood glucose curve and horizontal baseline going parallel to x-axis from the beginning of blood glucose curve at time 0 to the point at time 120 min) to reflect the total rise in blood glucose response after administering the tested foods. The following formula was used [10.] The Glycemic Index (GI) of a food was:

$$\frac{\text{IAUC}f\text{(above fasting baseline)}}{\text{Mean IAUC}g\text{(above fasting baseline)}} \times \frac{100}{1}$$

where:

IAUC*f*(above fasting baseline)= Incremental area under the blood glucose response curve above fasting baseline of a food.

Mean IAUC*g* (above fasting baseline) = Mean incremental area under the curve above fasting baseline of two determinations of the standard glucose [11].

2.6 Data Management

Every day, before each experiment the glucosure® plus blood glucose meter was calibrated using the codes by the manufacturer.Butthe code card found in the test strip package was for use with that particular package only.

2.7 Statistical Analysis

All the values of blood glucose and glycemic index were expressed as mean ± standard error (Mean± SE) and were performed using SPSS software package Version 21.0. The values were analyzed by one-way analysis of variance (ANOVA). A value of P< 0.05 was considered to be evidence for statistically significant.

3. RESULTS

The proximate compositions of twelve traditional Ethiopian foods are given in Table 1. The carbohydrate of these tested foods ranges from 10.4- 57.3 g/100 g. From this range white bread contained high carbohydrate content (greater than 50 g/100 g) and chickpea and pea sauce were low carbohydrate foods (less than 15 g/100 g). White and red teffenjera exhibited the highest fiber content (greater than 1.5 g/100 g) while bulla *genfo* was the lowest fiber (less than 1 g/100 g).

The glycemic indexes of twelve traditional Ethiopian foods were investigated in mice. The results of the mean glycemic index value of different traditional Ethiopian foods are given below.

Table 1. Proximate nutritional composition of twelve traditional Ethiopian foods considered in the study (Expressed as gram per 100 grams on fresh weight basis)

Compn Test F	Moisture (%)	Protein gram	Fat gram	CHO gram	Fiber gram	Ash gram	Nit(N) gram	Cal(Ca) (mg)	Phosp(P) (mg)	Iron(Fe) (mg)
White teff enjera	56.3	4.9	1.0	36.3	2.2	1.3	0.78	73.0	164.1	56.0
Red teff enjera	60.2	3.4	0.7	34.0	1.8	1.7	0.58	50.0	115.0	14.7
Maize enjera	60.2	4.4	1.3	33.5	1.2	0.6	0.71	2.4	111.1	9.8
Wheat bread	44.8	6.6	0.7	45.6	1.7	2.3	1.06	38.4	147.7	3.4
Maize bread	52.2	4.5	1.9	40.6	1.3	0.8	0.72	10.5	126.9	22.8
Barley bread	49.5	4.4	0.4	45.3	1.1	1.4	0.71	16.0	160.0	3.5
Pea sauce	75.3	6.6	2.9	11.8	1.0	3.4	1.06	43.6	115.7	16.8
Chickpea sauce	80.9	3.4	2.0	10.4	1.4	3.3	0.55	97.6	76.9	11.7
Lentil sauce	73.4	5.6	2.6	14.9	1.0	3.5	0.89	25.7	76.6	8.8
Qocho bread	52.9	1.6	0.1	44.1	1.4	1.3	0.25	71.3	98.8	2.8
Bulla *genfo*	77.3	0.1	3.8	17.9	0.2	0.9	0.01	18.3	1.9	0.6
White bread	31.4	6.8	4.3	57.3	0.3	0.2	1.08	3.4	45.5	0.5

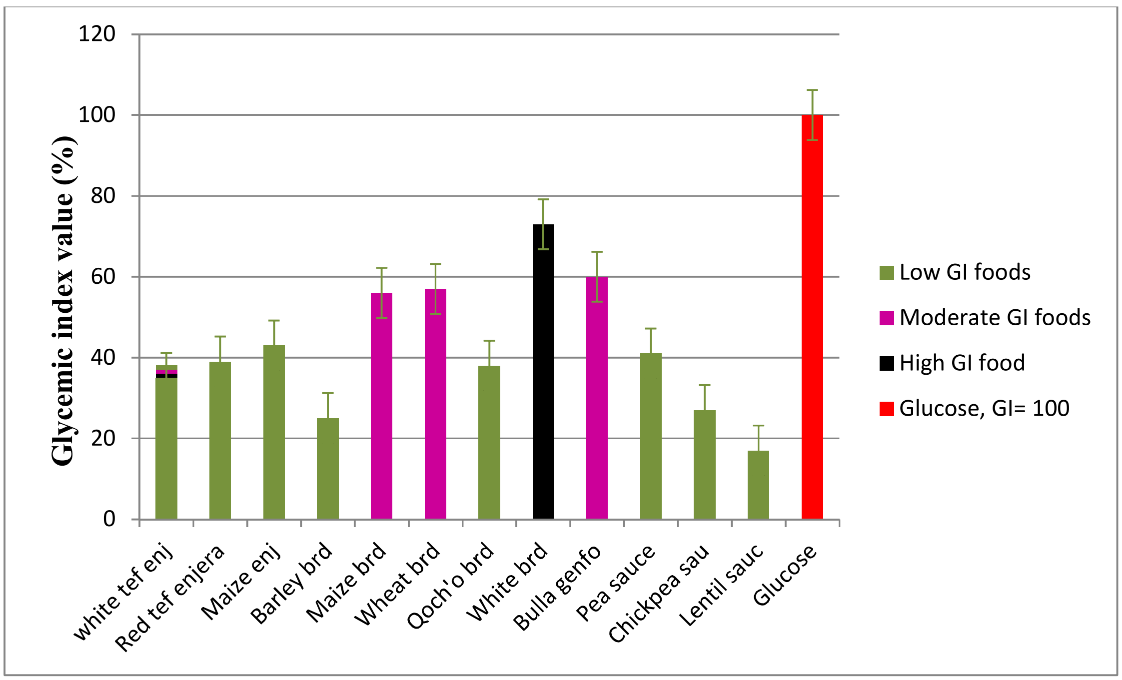

Fig. 1. The mean glycemic index (GI) with standard error (SE) values for the standard food (glucose) and the twelve traditional Ethiopian foods

4. DISSCUSION

The glycemic index (GI) of foods has been reported to be a marker of some beneficial effects [12]. Low glycemic index diets are important in the management of hyperglycemia and hyperinsulinimia. They are more effective per unit of energy, than most other foods in inducing satiety, these foods have a potential role in dietary strategies to avoid and treat diabetes and obesity [13]. Foods have been reported to produce different glycemic values depending on their chemical structure, particle size, amount and type of dietary fiber, fat, protein, anti-nutrient and food processing which may explain the variation among the carbohydrates of the food [14].

Processing of food has been reported to have effect on glycemic index [15]. Boiling, cooking, and heating result in alteration of the physical property of carbohydrates through gelatinization and retro gradation, thereby increase the starch availability to amylase [16]. The heat utilized, the amount of water, the time of cooking, all have a significant effect on the glycemic index [17], and this could also be attributed to the observed variation in the GI of the test foods. Chewing has been shown to reduce the particle size of foods and facilitates mixture with salivary amylase, thereby reducing digestion time of carbohydrate [15]. This is in conformity with reports that different foods with similar quality and type of carbohydrate form show different glycemic response [18].

Determinations of glycemic index of traditional Ethiopian foods are important for monitoring or balancing the blood glucose levels. The present study was designed to determine the glycemic index of twelve traditional Ethiopian foods. Among the twelve traditional Ethiopian foods, there were eight foods reported as low GI these are-; 1. White teffenjera, GI=35, 2. Red teffenjera, GI=39, 3. Maize enjera, GI=43, 4. barley bread, GI=25, 5. qocho bread, GI=38, 6. pea sauce, GI=41, 7. chickpea sauce, GI=27 and 8. lentil sauce, GI=17. From these eight low GI foods, maize enjera reported as highest glycemic response, GI=43, and lentil sauce was reported as the lowest glycemic response, GI=17. These low glycemic index (GI) foods have a number of positive health impacts; these include: (1) improved glycemic control in diabetic subjects, which is associated with reduced risk of diabetes, (2) more favorable lipid profiles, which are associated with lower risk of cardiovascular disease, and (3) reduced markers of inflammation, which are associated with lower risk of metabolic syndrome, overweight and other chronic diseases. For this reason low glycemic index foods are important to assist in disease prevention, especially the prevention of diabetes, cardiovascular disease, obesity, cancer and other chronic diseases of lifestyle [12]. From thetwelve traditional Ethiopian foods, there were three foods reported as having moderate GI: this are-; maize bread, GI= 56, wheat bread, GI= 57 and bulla *genfo*, GI=60. From the three foods, bulla *genfo* had the highest glycemic response (GI=60) and maize bread had the lowest response (GI=56). These low to moderate GI traditional Ethiopian foods are important for balancing (monitoring) blood glucose levels for diabetes mellitus.

The twelve traditional Ethiopian foods only one food was reported as having a high GI; this food was white bread (bread from bakery), GI =73. This high glycemic index food is quickly digested and enters the blood stream, quickly increasing the blood glucose rapidly. Increasing of blood glucose results in corresponding increase of blood insulin, promoting fat storage, increase cardiovascular risks, promote the development of type 2 diabetes and certain cancers [19]. The high glycemic index foods are positively associated with diabetes mellitus, other chronic disease such as cardiovascular disease and cancers. Therefore, white bread is not beneficial to control blood glucose for diabetic patients.

Pi-Sunyer [17] and David [20] reported that wheat bread and maize bread to produce moderate glycemic response. The present study also categorized wheat and maize bread as modetare GI foods, although higher carbohydrate content was observed.

Oboh et al. [13] reported the legumes to produce relatively high glycemic response in healthy individuals in Nigeria. The lower GI value of legumes (pea, chickpea and lentil sauce) in this study may be explained by their components particularly the soluble diet fiber and the nature of starch. Jimoh et al. [16] reported the cereals relatively produced high glycemic index in Kenya. The present study cereal produced low GI may be explained by high fiber content.

After preparing the tested food with different traditional methods, and then the foods were dried by sun light and oven (<85°C). The dried foods were manually grinded and the powders were kept in clean glasses at room temperature. The powder food (0.25 g) was weight dissolved in 1 ml of water administered in to each mouse (six).

According to the Table 1 (proximate nutritional composition) there is no correlation between glycemic index and protein and fat, for example, white bread shows the highest protein and fat contents and categorized under high glycemic index, but qocho bread contains lowest protein and fat and classified as the lowest glycemic index food, although numerous studies have shown that GI is lower with increased fat and protein content of many foods. Therefore, in this study there is no relationship between the glycemic index of protein and fat contents of foods.

The Mediterranean Diet (or Med Diet) reflects a way of eating that is traditional in the countries that surround the Mediterranean. Key elements of those choices include: Healthy oils, such as olive oil or canola oil, vegetables and whole grains, fish or seafood twice a week, very little red meat or eggs, e.t.c. There are many reasons to follow the Mediterranean Diet! Scientific evidence shows that it can help you: Achieve weight loss and weight management goals, lower risk of heart disease and high blood pressure, fight certain cancers and chronic diseases, reduce asthma, avoid diabetes, resist depression, nurture healthier babies, and ward off Parkinson’s disease.

Ethiopian traditional foods are also important for the prevention of different chronic disease and decrease the risk of development of disease including cardiovascular disease (CVD), coronary heart disease (CHD) and cancers. These foods contain legumes, cereals, especially enjera and root products.

Importance of teff *enjera*:

- **High Nutritional Value:** Teff is high in protein with a great combination of eight essential amino acids needed for the body’s growth and repair. It has high amounts of calcium, manganese, phosphorous, iron, copper, aluminum, barium, thiamin, and vitamin C. The iron from teff is easily absorbed and is also recommended for people with low blood iron levels. Naturally, this grain is very low in saturated fat (table 1)..
- **Gluten-Free**: Teff is a gluten-free grain so it can be a great alternative for those living with celiac disease, having gluten intolerance or choosing a gluten-free lifestyle.
- **Better Manage Blood Sugars:** Teff contains approximately 20 to 40 percent resistant starches and has a relatively low glycemic index (GI) that can help diabetics better to regulate their blood glucose levels.

Teff and celiac disease: This grain has very high calcium content, and contains high levels of phosphorus, iron, copper, aluminum, barium, and thiamin. A big advantage, according to soil and crop, is the fact that the iron from teff is easily absorbed by the body. Teff is high in carbohydrates and fiber. It contains no gluten, so it is appropriate for those with gluten intolerance or Celiac disease.

A test developed by the Leiden University Medical Center (LUMC) [20] has shown thatteff is completely gluten-free, meaning it can probably be accommodated in the diet of patients suffering from celiac disease. Celiac disease is caused by aberrant T-cell responses to wheat gluten and the gluten-like proteins in barley and rye. The only cure for the disease is a lifelong gluten-free diet. A cereal lacking T-cell–stimulatory peptides would thus be of great value to patients with celiac disease. It is also an alternative grain for people allergic to the gluten in wheat.

According to the proximate nutritional composition (Table 1) white teff enjera shows high iron content than red teff enjera because the iron content of the soil and its possible effect on the iron contents of the grain have been conducted, it may be possible that the high iron content of the soil contributes to the iron content of the grain. Therefore, the red color of red enjera is not due to iron but due to other plant pigments.

When to compare ***Mediterranean Diet*** and ***Ethiopian foods***: both contain cereals and legumes foods with high fiber, high protein and low saturated fats, these are important for healthy food choice, for the prevention of many disease. But in Ethiopia, red meatis a bigger part of the Ethiopian dietcompared with the Mediterranean diet, this food is not good choice because contains high amount of saturated fat, leads to increase the risk of cardiovascular disease by increasing cholesterol, triacylglycerol (TAG), and also increase fat storage, cause obesity and weight gain. These are risk factors for the development of chronic disease such as diabetes mellitus. Therefore, foods with high amount of red meat are not important for the prevention of cardiovascular disease in Ethiopia. Because high amount of red meat containcholesterol and triacylglycerol (TAG), these are the risk factors for the development of chronic disease like CVD and diabetes mellitus.

Generally using the glycemic index concept and determined the glycemic index value of Ethiopian traditional foods are important for diet selections, and that GI should be controlled for both treatment and prevention of chronic diseases (diabetes mellitus) [21].

5. CONCLUSIONS

The present study indicates that the scientific basis of the glycemic response of twelve traditional Ethiopian foods. The GI values for twelve tested foods were determined. A result from this study indicates eight foods were low, three foods were moderate and one was high glycemic index value of foods commonly consumed in Ethiopia.

Among the twelve traditional Ethiopian foods eleven foods (Eight were low and three were moderate) had a low to moderate glycemic index; these foods are important for people both with and without diabetes. These include reduction in the risk of developing type 2 diabetes and improvements in metabolic factors associated with long-term complications of type 1 and type 2 diabetes such as reduction of postprandial glycemia and insulinemia, improved glycemic control, improved lipid profile, and reduced risk factors of CVD.

From these traditional Ethiopian foods only one food had a high glycemic index (white bread), and this will likely increase the risk of development of many chronic diseases, especially diabetes mellitus, cardiovascular disease, obesity and cancer.

6. LIMITATIONS OF THE STUDY

- There is no standardized food processing and preparation methods, so simply traditional way of processing and preparation methods was done at one home, these may not be representative.
- The study was limited to few traditional Ethiopian foods due to the financial limitation.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENECES

1. Ludwig DS. Clinical update; the low glycemic index diet. Comment. The Lancet. 2007;369:890-892.
2. Englyst KN, Luis, Englyst HN. Nutritional characterization and measurement of dietary CHO. Eur J Clini Nutr. 2007;61(1): 519-539.
3. Laville. Could GI be the basis of simple nutritional recommendation? Invited comment. Br J Nutr. 2004;91:803-804.
4. Ruth L, Diane N. Prepared by Karin Westberg. Using the glycemic index to compare carbohydrates; 2003. Available:www.diabetesdigest.com/dd_nutrition2.htm, www.diabetesnet.com food/ diabetes diet/ glycemic index.php
5. Stevenson EJ, Williams C, Mash LE, Phillips B, Nute ML. Influence of high-carbohydrate mixed meals with different glycemic indexes. Am J Clin Nutr. 2006;84: 354-360.
6. Trenell MI, Stevenson E, Stockmann K, Brand-Miller J. Effect of high and low glycemic index recovery diets on intramuscular lipid oxidation during aerobic exercise. Br J Nutr. 2008;99:326-328.
7. Dickinson S, Hancock DP, Petocz P, Ceriello A, Brand-Miller J. High-glycemic index carbohydrate increases nuclear factor-kappaB activation in mononuclear cells of young, lean healthy subjects. Am J Clin Nutr. 2008;87:1188-1193.
8. Chen YJ, Wong SH, Wong CK, Lam CW, Huang YJ, Siu PM. The effect of a pre exercise carbohydrate meal on immune responses to an endurance performance run. Br J Nutr. 2008;9:1-9.
9. Sartorelli DS, Cardoso MA. Association between dietary carbohydrates and type 2 diabetes mellitus: Epidemiological evidence. Arq Bras Endocr Metabol. 2006;50:415-426.
10. Brouns F, Bjorck I, Frayn KN, Gibbs AL, Lang V, Slama G, et al. Glycemic index methodology. Nutr Res Rev. 2005;18:145–171.
11. Wolever TMS, Jenkins DJA, Jenkins AL, Josse RG. The glycaemic index: Methodology and clinical implications. Am J Clin Nutr. 1991;54(5):846–854.
12. Pawlak DB, Kushner JA, Ludwig DS. Effects of dietary glycaemic index on adiposity, glucose homeostasis and

plasma lipids in animals. Lancet. 2004;364: 778–785.
13. Oboh H, Osagie A, Omotosho A. Glycemic response of some boiled legumes commonly eaten in Nigeria. Diabet Croat. 2010;39:710-716.
14. Jenkins DJ, Kendall CW, Axelsen M. Viscous and non-viscous fibers, non absorbable and low glycemic index carbohydrates, blood lipids and coronary heart disease. Curr. Opin. Lipidol. 2000;11: 49-56.
15. Omoregie ES, Osagie AU. Glycemic indices and glycemic load of some Nigerian foods. Pak J Nutr. 2008;7:710-716.
16. Jimoh AK, Adedliron OS, Adebisi SA, Biliaminu SA, Okesina AB. Effect of food processing on glycemic response to white yam meals. Diabetol Croat. 2008;37:67-72.
17. Pi-Sunyer FX. Glycemic index and disease. Am J Clini Nutr. 2002;76(Suppl): 290S-298S.
18. Thorsdottir I, Bjorck I, Brigisdottir B, Steingrimdottir L, Flint A. Glycemic index; From research to nutritional recommendation. Ekpresson and Kopiceter, Denmark. 2005;1- 84.
19. Ludwig DS. The glycemic index: physiological mechanisms relating to obesity, diabetes and cardiovascular disease. JAMA. 2002;287:2414-2423.
20. Liesbeth Spaenij-Dekking, Ph.D. Yvonne Kooy-Winkelaar Frits Koning, Ph.D. Leiden University Medical Center 2300 RC Leiden, the Netherlands; 2005.
21. David Mandosa. Revised international table of glycemic index (GI) and glycemic load (GL) valuesl. Diabet Care; 2008.

Peer-review history:
The peer review history for this paper can be accessed here:
http://sciencedomain.org/review-history/20922