Original Research Article

A Pilot Study on Determination of Glycemic Index and Glycemic Loads of Commonly Consumed Food Items of Cassava and Sweet Potato of Bench Maji Zone, South West Ethiopia 2017

ABSTRACT

Introduction: Glycemic index is an important parameter designed to quantify the relative blood glucose response of foods in comparison with reference glucose. Determination of glycemic index and loads of carbohydrate-rich foods play as tools of nutritional guidelines for glycemic control and to reduce the risk of diabetic complications.

Aims: The aim of this study was to determine glycemic index and glycemic loads of cassava and sweet potato of commonly consumed food items of Bench-Maji, south west Ethiopia.

Materials and Methods: The 23 healthy subjects participated in the study from Ethiopia; the mean age was 27 ± 2 years. The matured cassava and sweet potato food items were processed by washed, peeled and cooked in water (gentle boiling at 90 C^{o}) for 20 minutes. Participants were informed to consume 50 g of carbohydrate portions of tested and reference foods. Blood sample was collected at 0 (fasting), 30, 60 and 120 minutes after ingestion of tested and reference foods. Glycemic index value of foods was calculated from the ratio of incremental area under the glucose curves of the foods. Glycemic loads for each food was determined from its glycemic index value and carbohydrate content. Data were statistically analysed by ANOVA and differences between means identified by the student t-test.

Results: The cassava and sweet potato had a medium glycemic indices (GI: 60), in spite of they generated high glycemic loads of 26 and 24 respectively. The cassava and sweet potato had significantly lower (P<0.0001) blood glucose response was noticed as compared to white bread. There was no difference of GI and GL of tested foods within the participants and statistically not significant (P>0.05).

Conclusion: This study showed that the cassava and sweet potato foods had a medium glycemic index and high glycemic loads. The tested foods had significantly lower blood glucose response

as compared to the reference food of white bread. The resulted GI and GL data of tested foods could be a help as a guide of food choices to control glycemic level and to reduce the risk of diabetic complications.

Key words: *Glycemic Index, Glycemic Load, Cassava, Sweet potato, Ethiopia*

INTRODUCTION

The glycemic index (GI) is an important parameter, which designed to quantify the relative blood glucose response of foods [1]. It was first measured in 1981 by David Jenkins for the purpose of the ranking carbohydrate-rich foods based on how they elevate blood glucose level after their intake (2). The glycemic index value is calculated by measuring the incremental area under the blood glucose curve following ingestion of a 50 gram of carbohydrate test food and compared with the area under the blood glucose curve following an equal intake of carbohydrate rich reference food (3). The numerical value of GI is determined by measuring of the incremental area under the blood glucose response curve (iAUC) for the test food is divided by the incremental area under the blood glucose response curve for the reference food and the result is multiplied by100(4). The GI of each food was then calculated as the mean value across all subjects consuming that food (5). The test foods are then assigned a category based on their 0-100 ranking and the glycemic index values are categorized into low when less than 55 , medium if the values found between 55-70 and high when its value is greater than 70 (3). Glycemic load (GL) refines the concept of glycemic index to quantify the impact that a carbohydrate-containing foods (1). The glycemic load value of a typical serving of each food was calculated by using the formula of: GL = GI × grams of carbohydrate in the typical serving size/100(5).

The Treads of Root Crops Production of Ethiopia

The socio-economic progress of Ethiopia depends on the performance of agriculture sector. The root crops in the country are covered by more than 1.62% of the small area under all crops in the country (6). The potato, sweet potatoes and taro cover 25.2%, 38.11% and 19.72% of the total root crop area respectively and these crops contributed about 23.35%, 38.44% and 17.74% of the total root crop production respectively in the Ethiopia (6). Cassava (Manihotesculenta Crantz) is an important root crop staple food for many countries including an Ethiopia (7). Cassava is rich in carbohydrates, calcium, vitamins B and C and essential minerals and inferior in protein and fat content, so that the soybeans are often used to balance the diet in cassava consuming area(8). However, the nutrient composition has been varied based on varieties, age of the harvested crop, soil conditions and climate (9). Sweet potato (*Ipomoea batatas*), is the most important food crops in the world due to its high yield and ranked as the seventh most commonly consumed carbohydrate-rich foods in the world (10). Ethiopia is ranked as fifteenth country in the world due to the production of sweet potatoes (11). Sweet potato is nutritionally high in carbohydrates contents and low in fat and protein constituents. It is also a good source of antioxidants, fiber, zinc, potassium, sodium, manganese, calcium, magnesium, iron, vitamin C and beta-carotene (12). The hypoglycemic activity response of sweet potatoes is associated with their resistant starch and digestibility (13).

The Role of Blood Glucose and Diabetes Mellitus

Glucose is utilized by the tissues and organs of the body for purpose of fuels and the precursor for conversion to other intermediate molecules (14). After a high carbohydrate diets, the blood glucose rises from a fasting level of 80-100mg/dl(5mM) to 120-140mg/dl(8mM) within a period of 30 minutes to one hour and regulated in a narrow range(14). Within subsequent increase in blood glucose will also trigger the release of the insulin hormone from pancreatic beta cells (15,16). Diabetes mellitus is a chronic metabolic disorder characterized by the persistent of hyperglycemia due to defective insulin secretion or defective insulin action(17). The prevalence of diabetes mellitus has been increasing from time to time in the world (18) of affecting more than 366 million peoples and its number is expected to rise to 552 million by 2030, due to the consequence of urbanization, obesity, sedentary lifestyles and other factors (17). Ethiopia is the second most populated country in Africa and currently challenged by the growing magnitude of chronic non-communicable diseases like diabetes and its prevalence in Ethiopia is around 1.9%, this is because of ageing of the population and lifestyle associated with rapid urbanization (18). DM is mainly categorized as type 1 diabetes mellitus, type 2 diabetes mellitus, and gestational (19). Type 1 diabetes mellitus (T1DM) is typically a result of an autoimmune-mediated process in which pancreatic β-cells are destroyed resulting in absent insulin production (20). Type 2 diabetes mellitus (T2DM) is characterized by the presence of chronic hyperglycemia, which results from resistance to insulin actions on peripheral tissues (20). Most of the complications of diabetes mellitus are is associated with chronic hyperglycemia and increased generation of oxygen derived free radicals, which may lead to damage and failure of the kidneys, eyes, nerves, heart and blood vessels (18).

The Role of Nutrition and Management of Diabetes mellitus

The excess consumption of high glycemic index foods can lead to hyperinsulinemia, insulin resistance, weight gain and obesity (21). The development of diabetes mellitus, obesity, cancer and cardiovascular disease has been reported to be linked to high glycemic index foods (22). The studies have shown that there was a positive correlation between the consumption of foods with a high glycemic index and increased risk of chronic disease such as diabetes (21). The nutrition plays a key role in the management and treatment of diabetes mellitus, thus foods with a low glycemic index can be beneficial in reducing the incidences of chronic diseases by avoiding uncontrolled postprandial glucose load (13). WHO recommended that the GI of foods be used in conjunction with information about food composition to guide food choices and at least 55% of energy be derived from carbohydrate and should be rich in dietary fiber and low glycemic index ranking (23). The consumption of foods with low glycemic index has several health benefits, these include reduced insulin demand, improved blood glucose control, weight losing and reduced blood lipid levels benefits by reducing the rate of carbohydrate absorption. In fact that some foods on the world market have been showing their glycemic index rating on the nutrition information panel (3).

In view of these facts, it is important to determine the glycemic index and glycemic loads of cassava and sweet potato foods to provide information on the GI and GL to guide food choices and avoid uncontrolled postprandial glucose load that could help to guide food choices for management and prevention of DM complications. Although, there is no studies have been conducted on the information of the glycemic index and glycemic load of cassava and sweet potato foods of Ethiopia. Therefore, the aim of this current study is to determine the GI and GL values of commonly consumed cassava and sweet potato of Bench-Maji, South West of Ethiopia.

MATERIALS AND METHODS

Study design and period

An experimental based study was conducted on 23 healthy participants in Mizan-Aman town of Bench Maji Zone Southwest Ethiopia. Mizan-Aman has located 581 km from Addis Ababa of Ethiopia. In Bench Maji Zone, there are 15 government health centers, 11 medium private clinics and one teaching referral hospital found. The data for the study were collected from September 30, 2016 to February 30, 2017 for five consecutive months.

Selection of Study Populations

A total of 23 healthy participants from Mizan-Aman town and staffs of the Mizan-Tepi University were included in the study. The participants were physically examined by a medical doctor on the basis of the following criteria: age 20 to 60 years; body mass index 20 to 25 kg/m^2 (WHO criteria) and whose fasting blood glucose value (at time 0 min) between 70-126 mg/dl and when to calculating IAUC only the area above the fasting level were recruited in the study. Informed consent was obtained from participants before recruitment into the study. The active gastrointestinal (e.g. celiac disease), first-degree family history of diabetes, smokers, pregnant women's, renal failure and the blood glucose value fell below the baseline when to calculating IAUC were excluded from the study.

Preparation of the research foods

Two most commonly eaten freshly harvested, matured tubers root crops of the cassava and sweet potato cultivars were purchased from local markets of the Bench Maji Zone, south west Ethiopia to determine their glycemic index and glycemic loads. The cassava and sweet potato food items were processed by washed, peeled and cooked in water (gentle boiling at 90 C^o) for 20 minutes. Then, these foods were cut into 50 grams available carbohydrate portions for GI and GL determination. White bread was gently prepared by bakery's professional as the reference food. The participants of the study were instructed to report the laboratory of the department teaching hospital of Mizan-Tepi University after overnight fast. The each participant was reported to three consecutive days and particular foods item was assign to each individual. Blood sample was collected and glycemic index and glycemic loads analysis of foods were carried out by Wolever et al. (24) study protocols.

Data collection procedure

All the study participants were willing to respond to the investigators based administered questionnaires and then to give the required volume of blood. The anthropometric data of study population was obtained from measurement of body weight and height, waist and hip circumference to calculate the BMI and WHR respectively. Blood pressure was done by using digital measuring device prior to sample collection. Then three BP measurements were taken after participants sitting for at least five minutes were carried out by trained nurses. The blood sample for the biochemical analysis was carried out by trained laboratory technicians.

Laboratory Sample Collection for Glycemic index and Glycemic loads

The blood sample from finger capillary was taken from each participant on each day at various time points by employing infection prevention procedure. The first blood sample was taken while the individuals from overnight fasting (0 minute fasting blood), followed by second, third and fourth blood samples at 30, 60 and 120 minutes after the ingestion of tested foods respectively. Blood sample was collected from a finger prick using a hypodermic needle of the individual participant was placed on a test strip and inserted into a calibrated Gluco-meter (Accu-Check/One touch) which gave direct readings after 45 seconds based on glucose oxidase assay method. The blood glucose response level of each tested foods was analyzed at intervals of 0 (fasting level), 30, 60 and 120 minutes respectively at laboratory department of the teaching hospital of Mizan-Tepi University.

Determination of Glycemic index and Glycemic loads of foods

Determination of the blood glucose response level was done at the intervals of 0, 30, 60 and 120 minutes respectively. The blood glucose values were plotted against time and the area under blood glucose curve (AUC) 2hrs of each eaten foods by study participants was measured. The glycemic index values of each tested foods of each study participant were calculated by the method of Karim et al. (25), by dividing their glucose AUC for the test food by their glucose AUC for the reference food (white bread). Glycemic load of each test was calculated as the GI (%) multiplied by the grams of carbohydrate in the serving of food eaten by study participants by the method of Farunkh et al. (26).

Data Quality Control

The questionnaire was translated to Amharic and translated back to English. Two days training was given for data collectors. Pre-test was done on (5%) of our sample size in Mizan-Aman town residents who were not part of the study participant. Based on the finding of the pretest, the questioner was revised. The participants were informed about the confidentiality of their information. The quality of biochemical parameters was kept by aseptic techniques and analyzed carefully on the calibrated Gluco-meter of following standard operating procedures. The data collectors were supervised and checked daily by the principal investigators for completeness and errors were identified and corrected.

Statistical Analysis

The collected data were entered and analyzed using SPSS version 20. Descriptive statistics (frequency, mean, median, standard deviation and percentage) were used to describe socio-demographic characteristics of the study participant. Changes in the blood glucose response level after consumption of tested diets (cassava and sweet potato) by time interval was expressed as mean ± SD. Glycemic index and glycemic loads of tested diets were also expressed as mean± SD. The significant difference between the GI and GL values between the foods was assessed by student t-test and ANOVA. A p-value of < 0.05 was considered to be evidence for statistically significant.

Ethical consideration

The ethical approval letter was obtained from the Institutional Review Board of Mizan-Tepi University. The confidentially and anonymity was assured by assigning codes to each study participants and the code was kept confidential. Name and address of the participants were not taken and participants were informed about the aim of the study, the advantages of the study, and their rights even to stop in the middle of the procedure. The written informed consent was taken before data collection.

RESULTS

Basic anthropometric characteristic of the study populations

Total of 23 participants from Mizan-Aman residence and staffs of Mizan-Tepi University were included in the study. Among the 23 participants sixteen (74%) were males and seven (26%) were females. The mean age of the participants was 26±4.84years with the minimum and maximum ages of 20 and 37 years, respectively (Table1). As table 1 describes the mean value of body mass index of the participants was 24.64±2.62 kg/m^2. The mean value of waist to hip ratio of the study participants was 0.80±0.36 with the male and female of 0.81±0.038 and 0.791±0.013 waist to hip ratio respectively (Table1). As described in table 1, the mean waist circumference, hip circumference of participants was 61.3±5.40, 75.69±6.95 respectively. The mean value of systolic blood and the diastolic blood pressure of participants were 121.73 ± 0.3mmHg and 90.39 ± 9.15mmHg respectively (Table1). The mean value of SBP and DBP of male participants was 122.17±13.96, and 90.29±9.53 respectively. The mean value of SBP and DBP of women were 120.50±6.15and 90.66±8.84 respectively (Table1).

Table 1: Basic anthropometric characteristics of study participants

Basic anthropometric and clinical characteristics of participants	Mean values of (mean+ SD)	p-values
Age	26±4.84 years	P<0.001
BMI (kg/m^2)	24.64±2.62 kg/m^2	P<0.001
WHR	0.80±0.36	P<0.001
Wc	61.30±5.40	P<0.001
Hc	75.69±6.95	P<0.001
SBP (mmHg)	121.73±12.30	p>0.05
DBP (mmHg)	90.39±9.15	p>0.05

*Data presented as mean ± standard deviation, BMI-body mass index, WHR-waist-hip ratio, SBP-systolic blood pressure, DBP-diastolic blood pressure, Wc-waist circumference. Hc-hip circumference.

Proximate Composition Analysis of Foods

The nutrition proximate composition cassava and sweet potato were determined according to AOAC methods (27). As noted in table 2 below, the mean proximate composition analysis results of cassava was 54.2±0.10% moisture, 0.05±0.003% ash, 1.16±0.03% dietary fibre, 0.77±0.001% fat and 1.02±0.03 % protein. The sweet potato had an average of 53.5±0.45% moisture, 1.06 ± 0.03% ash, 2.12±0.25% dietary fiber, 0.67 ± 0.06% fat and 1.16 ± 0.05% protein. The carbohydrate contents of diets were determined by difference, the 50g of available carbohydrate for each test food sample was calculated from the results of the proximate analysis and the measured portion of the diets was served to the subjects. The carbohydrate content of cassava proximate composition analysis was 42.83g/100g, which is less than 50g/100g and carbohydrate content of sweet potato was 40.37g/100 g, it is also less than 50g/100g. However, cassava contained high carbohydrate content than sweet potato based on the proximate composition analysis of this current study.

Table2: Proximate analysis of processed cassava and sweet potato foods (in dry weight percent).

Components of foods	Moisture (gram %)	Ash(gram)	Protein (gram %)	Fat(gram%)	Dietary fiber (gram %)	Available CHO (gram %)
Cassava	54.2±0.10	0.05±0.003	1.02±0.03	0.74±0.001	1.16±0.03	42.83±0.05
Sweet potato	53.5±0.45	1.06 ± 0.03	1.36 ± 0.05	0.69 ± 0.06	2.12±0.25	40.37 ±0.03

gr; gram percent, CHO: carbohydrate

Analysis of Glycemic index and Glycemic loads of foods

The mean blood glucose level of each participant was measured after consumption of 50 g of carbohydrate contents of tested foods and reference (white bread) with 30 minute intervals of 0 minutes, 30 minutes, 60 minutes, 120 minutes. The blood glucose response curve versus time was obtained by plotted a graph thus: x-axis, time interval and y-axis, blood glucose concentration. The mean of the respective blood glucose response before and after consumption of the foods was used to draw a blood glucose response curve for the two hours period. The incremental area under the curve (IAUC) was calculated for each food in every participant 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 the blood glucose response after administration of tested foods.

Glycemic index of tested foods was determined according to the following formula of Brouns Fetal.(28), Glycemic index (GI)=

$$\frac{\text{IAUCf(above fasting baseline)} \times 100}{\text{Mean IAUCr(above fasting baseline)} \times 1}$$

Where:

IAUCf(above fasting baseline): incremental area under the blood glucose response curve above fasting baseline of food. Mean IAUCr(above fasting baseline): Mean incremental area under the curve above fasting baseline of two determinations of the reference foods (5). The glycemic loads (GL) of a typical serving of each tested foods was calculated by using the method of Camille A. et al. (5):

$$GL = (GI \times \text{grams of carbohydrate in the typical serving size}/100$$

The mean glycemic response level of foods of study participants

The table 3 and figure 1 below shows the mean glycemic responses of cassava and sweet potato and white bread of the participants. The mean blood glucose level of cassava was70.95±3.03, 73.03± 4.44, 75.22 ±3.62 and 73.22±3.85 at the 0, 30, 60 and 120 minutes respectively. The mean blood glucose level of sweet potato was 71.61±2.48, 74.24±3.6, 73.86 ± 3.71 and 73.16± 2.40. On the other hand, the reference food (white bread) had the mean blood glucose level of 104± 21.8, 114±15.74, 120±14.67 and 129.30±12.56. There was no statistically significant difference in blood glucose level within the study participants ($P>0.05$). However, there was a statistically significant difference in blood glucose level within and white bread of reference foods of participants since ($P<0.0001$).

Comparison of blood glucose level of foods of study participants

Table 3 below indicates the extent of the difference between individual tested foods with the reference food of blood glucose response of participants. The mean difference of cassava when compared to reference food of white bread had significantly lower ($P<0.0001$) of participants. The mean difference of blood glucose response of sweet potato was significantly lower as compared to the white bread of the participants ($p < 0.0001$).

Table 3: Mean glycemic response level of foods of study participants

Time interval	**Incremental Area Under The Glucose Response Curve (IAUC)**			
	Sweet potato (2hrs)	Cassava(2hrs)	White bread (reference)	Difference level of foods(P -value)
0 minute	71.61±2.48	70.85±3.04	104.0±21.8	(P<0.0001)
30minutes	74.24±3.61	73.03±4.44	114.0±15.74	(P<0.0001)
60 minutes	73.86±3.71	75.22±3.62	120.05±14.67	(P<0.0001)
120 minutes	73.16±2.40	73.22±3.85	129.30±12.56	(P<0.0001)

**Statistically significant at (P<0.0001)

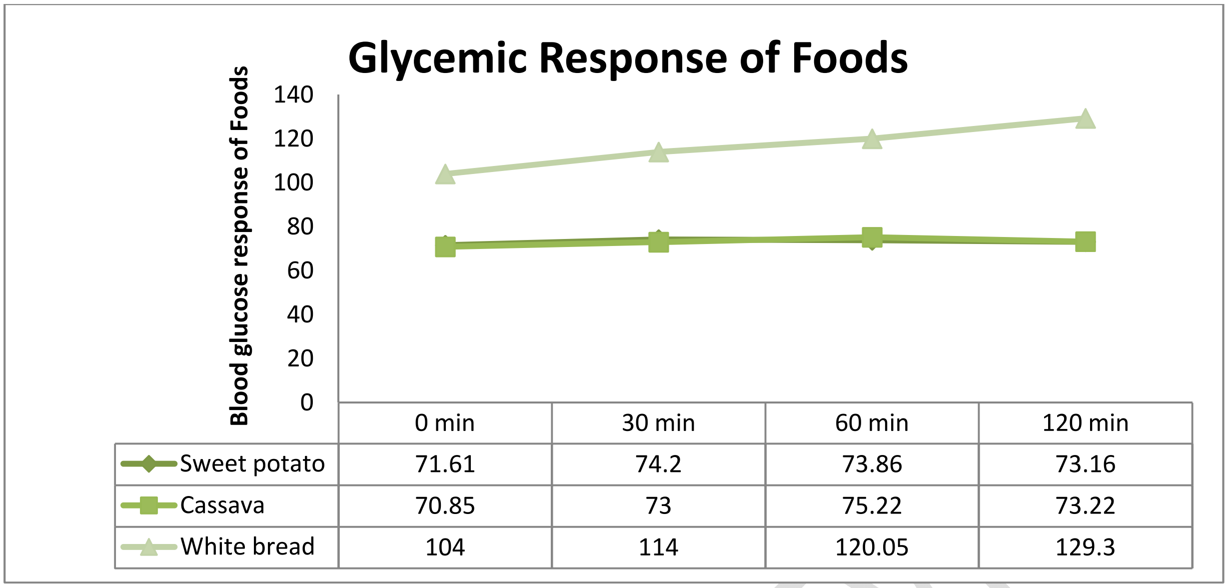

Figure 1: Graghic representation of the glycemic response of cassava, sweet potato and white bread.

Glycemic index and Glycemic load of Cassava and Sweet potato of Participants.

Table 4 and figure 2 below indicates the glycemic index and glycemic load results of the tested foods of study participants. The mean glycemic index and glycemic load values of cassava were 60.81±2.73, 26.04±1.36 respectively. The mean glycemic index and glycemic load values of sweet potato were 60.61±2.25 and 24.46±1.12 respectively. The mean difference of the blood glucose response of tested foods (cassava and sweet potato) had lower values and statistically significant at ($p < 0.0001$) when compared to the reference food of white bread.

Table 4: The glycemic index and glycemic load of the cassava and sweet potato foods

Tested food items	Available carbohydrate content(gram)	Glycemic Index	Glycemic Load
Cassava	42.83gram	60.81±2.73	26.04±1.36
Sweet potato	40.37gram	60.61±2.25	24.46±1.12

*Data presented as mean ±standard deviation.

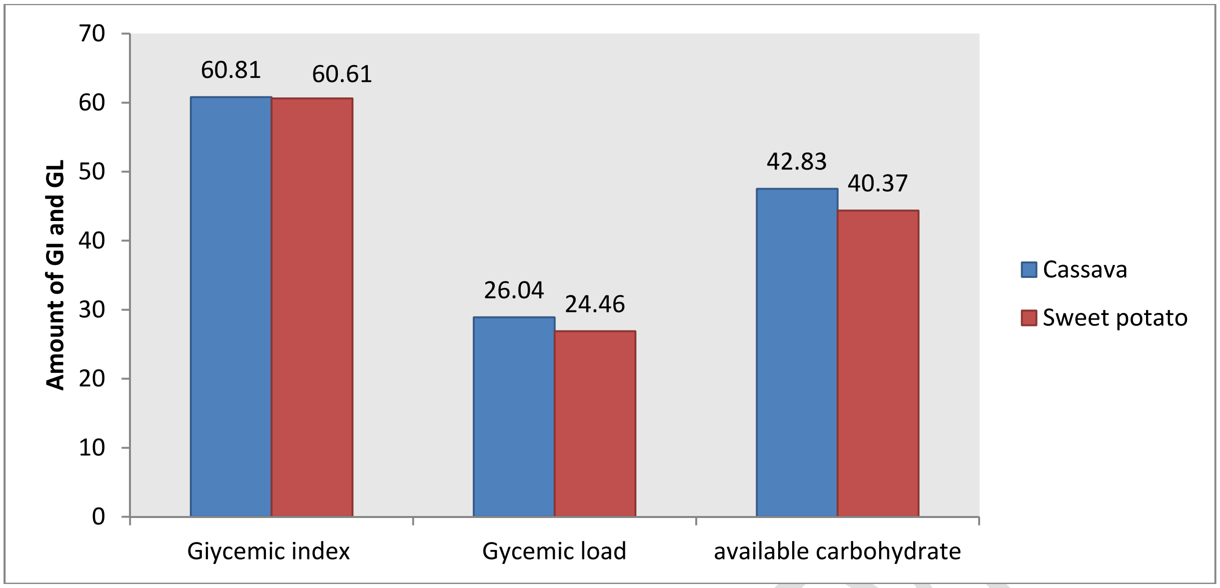

Figure2: Graphic presentation of glycemic index and glycemic loads of tested foods

Discussion

Carbohydrates play a major role in providing cellular fuels and other metabolic intermediate molecules of the body. However, the glycemic response of particular diets that rich with high carbohydrates is regulated in a narrow range to control plasma glucose levels (26). In fact that, in response to an elevated level of blood glucose, insulin hormone regulates uptake of glucose from the blood into most cells for energy and conversion to other molecules (17). Glycemic index is used to measure of how quickly a carbohydrate food affects the blood glucose levels and the effect of carbohydrate-containing foods on blood sugar level can be compared with the effect of reference glucose to ascertain a particular food glycemic ranking (21). So that the carbohydrate foods based on the response of blood glucose levels can be classified as a high and low glycemic index (29). Numerically the glycemic indexes of various foods are categorized as three groups such as foods with GI ranges from 0-55, 56-69 and 70-100, are low, medium and high respectively (29). Categorizing of how rapid or slow a carbohydrate food is transformed into glucose after eating is an estimation of its glycemic index (26). Studies conducted by Allen et al.(29), indicated that dietary management is a necessity in obtaining an improved glycemic control to lessen the possibility of diabetic complications.

In the present study, the mean glycemic response value of the cassava with respect of time interval was 70.95±3.03, 73.03± 4.44, 75.22 ±3.62 and 73.22±3.85 of the 0 minutes, 30minutes, 60minutes and 120minutes respectively. The mean value of white bread blood glucose level was 104± 21.8, 114± 15.74, 120±14.67 and 129.30±12.56 with the 0 minutes, 30minutes, 60minutes and 120minutes respectively. Mean glycemic response level of cassava was significantly lower (P<0.0001) when compared to glycemic response of reference food of white bread in the participants. The present study has shown in the table 4, the mean glycemic index and glycemic load values of cassava were 60.61±2.25 and 24.46±1.12 respectively.

Cassava is one of the largest sources of carbohydrate and consumed by peoples of many countries in the world, despite lower in protein and fat content when compared to rice and potatoes(7). The result of the current study shows that the GI of cassava food had the medium GI and high GL values. The blood glucose response of the cassava had lower than the reference food of white bread. The medium glycemic index value of cassava of Ethiopian was recorded, the study conducted by Foster-Powell et al.(2) also revealed that cassava root crop foods had medium GI values. The current study results also agreed with the finding of Brand-Miller J, et al. (30). However this present study finding is not supported by another study (31) of Nigeria as a result, the cassava had GI ranging from 82 to 99, this indicates that their shows that the cassava generated high GI. This variation of between GI of this current and Nigeria studies might be due to high carbohydrate contents of cassava, (80% dry weight) and the presence of gelatinised starch.

Another study conducted by Camille A. etal. (5) is not in agreement with the present study, authors indicated that the cassava had a high glycemic index. The variation of GI value of this current study with another former published study probably due to the carbohydrate fraction and its starch (29). The studies indicated that different cooking methods affect glycemic index values of foods, Therefore, cassava produces a medium glycemic index of the present study might be due to lower rates of gastric emptying and digestion of carbohydrate in the intestinal lumen (32). The same study by Perceval etal.(21) of also found that the effect of various cooking methods influence the glycemic index of cassava. The method of processing and cooking of an individual food can greatly change. These are induced by disrupting the amylose/ or amylopectin structure of the starch complex and making it more accessible to digestive enzymes (5). The studies revealed that the GI values also influenced by the type of food, the degree of food processing and cooking and the presence of fructose or lactose. The ratio of amylopectin and amylose in starch (amylose has a slower rate of digestion); starch- protein/ or fat -interactions (24).

This study shows that the cassava had a high glycemic load value. This is also confirmed with the study have documented by Brand-Miller J, et al. (30), their finding indicated that GL values of different food based on food portion provided a high level of GL values. This current study is also consistent with the finding (33) that the authors reported with high GL. Similarly, study done by Kouamé et al. (34) also reveals that the foods had higher GL values, this increased level of GL level of food is because of their quality and the nature of starch. So, their consumption should be limited because they could increase the insulin response. But the other study conducted (2), is not in agreement with the current study of GL values; this might be due to different portion of foods and different cooking methods, that affect the values of glycemic loads of foods (30). The finding of Farukh etal.(26) of their studies described that glycemic load measures the degree of glycemic response and insulin demands produced by a specific amount of specific food and helps to predict blood glucose response to a specific amount of specific carbohydrate food.

Sweet potatoes are the most important carbohydrate-rich root crops (26). The mean glycemic response level of sweet potato of the present study was 71.61±2.48, 74.24±3.6, 73.86 ± 3.71and 73.16± 2.40 of the 0 minutes, 30minutes, 60minutes and 120minutes respectively. The sweet potato blood glucose response level of this study was significantly ($P < 0.0001$) lower when compared to the reference food of white bread. The mean glycemic index of sweet potato of this study was 60. As a result, sweet potato of Ethiopian foods was reported as having medium glycemic index value. This current study result also similar with study done by *Allen* etal. (29), the authors confirmed that the cooking methods of sweet potato by boiling had a medium glycemic index. The other studies finding by the authors of Foster-Powell et al.(2) and Farukh etal.(26) GI values of sweet potato also similar with the present study result. The current study result of sweet potato GI value is agreed with the finding of Perceval etal.(21), their studies indicated that consumption of boiled sweet potato had a medium GI value and that could minimize postprandial blood glucose spikes and that may be used for the management of diabetes mellitus.

The hypoglycemic activity response of sweet potatoes is associated with their resistant starch and digestibility (29). The foods with low starch digestibility tend to have high hypoglycemic activity (13). Sweet potato may be considered low and medium glycemic index foods, which may prove beneficial for diabetic or insulin-resistant consumers (26). The other study indicates that the glycemic index of sweet potatoes varies with the method of preparation and cooking (26). The studies indicated that different cooking methods affect glycemic index values of foods. The finding of Perceval etal.(21), also found that the effect of various cooking methods influence the glycemic index. They also further described that during the boiling, heating breaks down starch granules to allow amylopectin and amylose to be more readily digested by pancreatic amylase (26). The variability in glycemic index could be the result of a different year's crop, time in storage, or slight differences in preparation method(29). The ratio of amylopectin and amylose in starch (amylose has a slower rate of digestion); starch-protein or starch-fat interactions (24).

The mean glycemic load value of sweet potato of this study was 24. The result of this current study is consistent with the finding of an earlier published study (33), reported high GL. Similarly, the other study was done by Camille A. et al. (5)

reported that the foods had higher GL values. This increased GL level of food might be due to their quality and the nature of starch. According to Brand-Miller J, et al. (30), the GL values of different food based on food portion.

The amount and type of carbohydrate are the main dietary factors affecting postprandial glycaemia as described by the relationship between the GI values and protein, fat and dietary fiber content (29). However, the cassava and sweet potato of this current study was contains lowest protein and fat and had a medium glycemic index. Despite the variation of dietary fiber, protein and fat contents, there were no correlation between glycemic indices and protein and fat with GI of tested foods. This finding is also consistent with the findings of conducted by Kouamé etal. (34).

Conclusion

The glycemic index is an important parameter, which is designed to quantify the relative blood glucose response (hyperglycemic effect) of foods in comparison with reference glucose. This study showed that the tested foods (cassava and sweet potato) had a medium glycemic index and high glycemic loads. The cassava and sweet potato also significantly had lower blood glucose response levels as compared to reference (white bread) food in the study participants. The finding of the current study indicated that both foods had moderate glycemic indices and high glycemic loads. The resulted data of GI and GL from cassava and sweet potato foods could help to guide food choices and avoid uncontrolled postprandial glucose load for better prevention and management of DM complications. Furthermore, the GI and GL data of this study can serve as a tool for health workers involved in meal planning for diabetics and diabetes education program. The study suggests that another research should be conducted on the relationship between GI and GL values of foods with gender by enrolling a larger number of subjects and different varieties of the root crop foods.

Abbreviations

ADA: American diabetic association

ANOVA: Analysis of variance

AUC: Area under curve

AOAC: Association of official analytical chemistry

BMI: Body mass index

BP: Blood pressure

CHO: Carbohydrates

SBP: Systolic blood pressure

DBP: Diastolic blood pressure

CDA: Canadian diabetes association

DM: Diabetes mellitus

IDF: International diabetes federation

T1DM: Type 1 diabetes mellitus

T2DM: Type 2 diabetes mellitus

GI: Glycemic index

GL: Glycemic load

Hc: Hip circumference.

Kg/m^2: Kilogram per meter square

IAUCf: Increment area under curse of diets above fasting baseline

IAUC r: Incremental area under curve of reference above fasting baseline

Min: Minutes

Mg/dl: Milligram per deciliter

MmHg: Millmeter mercury

SD: Standard deviation

SPSS: Statistical package for social sciences

WHR: Waist to hip ratio

Wc: Waist circumference

WHO: World health organization

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