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Full Length Research Paper

The glycemic index and load of different Nigerian food forms

Evans Egwim C and Gajere Y.

Department Of Biochemistry Federal University Of Technology, Minna Niger State Nigeria
Corresponding Author E-mail:- evanschidi@gmail.com
Phone no: - +2347065809474, +2348065620363

ABSTRACT

The knowledge of glycemic index (GI) and glycemic load (GL) of foods is essential for rational advice on calorie recommendation. Unfortunately, the GI and GL of many Nigerian food forms is not known and so the present study was designed to classify 30 Nigerian food forms into low, moderate and high glycemic loads (HGL). Eighteen (18) human volunteers, aged 16-24 years with a mean body mass index (BMI) of 22.59±1.51kg/m^2 were recruited and were separated into different groups to consume the test food forms consisting of 50g available carbohydrate (CHO) from different Nigerian food forms. Fasting blood glucose of the subjects was evaluated using Accu-chek active glucometer. The area under curve (AUC), GI and GL for the different food forms were calculated. The outcome of the analysis showed that 26.67% of the 30 Nigerian food forms are high GL food, 53.33% are moderate GL and 20.00% are low GL foods.

Keywords: glycemic load, glycemic index, Carbohydrate, incremental area, glucose.

INTRODUCTION

The concept of glycemic index (GI) was introduced as a means of classifying different sources of carbohydrates (CHO) and CHO-rich diets. The classification is according to their effect on postprandial blood glucose level, different carbohydrate containing foods have different effects on blood glucose response (Jenkins *et al.,* 1981; Wolever, 1990; Brouns *et al.,* 2005).

GI refers to ranking of foods that have the ability to raise blood glucose concentrations, relative to a standard food (glucose or white bread) (Jenkins *et al*., 1981). According to GI Task Force (2002) GI was defined as "the incremental area under the curve for the increase in blood glucose after the ingestion of 50g of glycemic carbohydrates of a test food in 2-hours for the healthy and 3-hours for diabetic individuals from the start of the test meal, as compared with ingestion of the same quantity of glycemic carbohydrate from glucose taken with 300 ml of water over a 10-15 minute period, which is in accordance to a defined laboratory procedure in the same individual under the same condition using fasting blood glucose concentrations as baseline."

Low-GI CHO is the CHO that is digested and absorbed slowly and led to a low glycemic response, whereas high-GI CHO is rapidly digested and absorbed and shows a high glycemic response (Brouns *et al*., 2005). The rate of glucose entry into blood and the duration of the elevated blood glucose induce many hormonal and metabolic changes that may affect health and disease parameters (Hodge *et al*., 2004).

Evidence from prospective studies shows the intake of low GI-diets are associated with reduced risk of diabetes (with specific reference to type 2 diabetes) (Hodge *et al*., 2004; Frost *et al*., 1998), cardiovascular disease (Liu *et al*., 2000), cancer (Augustin *et al*., 2003; Augustin *et al*., 2004), and the metabolic syndrome (Mckeown *et al*., 2004). Low GI foods improve overall blood glucose control in people with type 2 diabetes (Wolever *et al*., 1992), reduce serum lipids in hypertriglyceridemia patients (Jenkins and Jenkins 1987) and improve insulin sensitivity (Riccardi and Rivellesse, 2000; Augustin *et al.*, 2002; Slyper, 2004). Also, the intake of a low GI-diet is associated with higher concentrations of high-density lipoprotein (HDL) cholesterol (Frost *et al*., 1999) and significant reduction in low density lipoprotein (LDL) cholesterol as well as total cholesterol (Opperman *et al*., 2005). When low glycemic CHOs, get incorporated into an energy restricted diet, compared to higher glycemic CHOs, it leads to a reduction in insulin resistance that cannot be accounted for by weight loss alone (Slabber *et al.,* 1994). According to Agus *et al*., (2000), low-GI diets influence weight loss and resting energy expenditure independently of energy intake in young moderately overweight subjects.

Modern life habits are characterized by low daily energy expenditure and by the excessive ingestion of foods rich in carbohydrates and lipids, making the positive energetic balance a reality. The consequence is the increase of the body mass index (BMI) and the prevalence of obesity, in developed as well as developing countries. (Barreto *et al*., 2005; Blair and Church, 2004).

Several works by Roberts, (2000) and Gulliford *et al* (1989) have shown that glycemic CHO leads to hunger and CHO craving. Slyper, (2004) demonstrated increased satiety, delayed return of hunger, and decreased food intake, after ingestion of low-GI compared to high-GI foods. The consumption of High glycemic load diet has its dire health consequences, this type of diet is responsible for the increase of the prevalence of obesity (Ebbeling *et al*., 2003; Ludwig, 2002; Silva and Alfenas, 2011), which might lead to the alteration of the oxidative state and inflammatory markers, besides favouring lipogenesis, hyperglycemia, hyperinsulinemia, reduction of insulin sensibility, hypertriglyceridemia and decrease the concentration of HDL-cholesterol in the blood (Frost, *et al* 1999).

The Joint FAO/WHO expert in 1998 endorsed GI usefulness in diet planning caption “Carbohydrates in Human Nutrition” due to its beneficial effects to health (Riccardi and Rivellesse (2000). According to the report of Hu *et al*., (2000), eating habit characterized by the consumption of high glycemic index (HGI) and high glycemic load is a measure that incorporates both the quality and quantity of dietary carbohydrate. It takes into account the GI and its impact on body system (Wylie-Rosett *et al*., 2004)

MATERIAL AND METHODS

Preparation of the Meals

All the food forms were prepared in the same way they are prepared for eating in the homes. The meals were prepared as follows:

1. Boiled yam: peeled yam was sliced and 175g was weighed and cooked to boiling for 30 minutes until softened, salt was added to taste, and served with 30ml stew

2. Pounded yam: peeled yam was sliced and cooked until softened as in (1) above and pounded in a mortar using a pestle to smooth the dough and eaten with soup.

3. Fried yam: peeled yam was sliced and deeped fried for 15 minutes until light brown and served with stew.

4. “Amala”: it was prepared from processed yam flour. In Nigeria, the browned yam flour “elubo” is traditionally made by parboiling yam chips at about 80℃ till the chips are pliable, then the chips are sun-dried for about 72 h and grind into flour. The yam flour was reconstituted in boiling water and cooked for 20 minutes with continuous stirring until a thick brown or grey-colored smooth paste was formed, which is referred to as Amala. (Akingbala, 1995) and served with 30ml stew mixed with draw soup and a muscle of meat weighing at least 30g

5. Yam porridge: peeled yam was sliced into smaller pieces and 175g was weigh and cooked until softened. 10g of amaranthus, 5g tomatoes, 5g onions, 2 maggi cubes and 20ml of red oil boiled for 25minutes to make the porridge palatable.

6. White rice: eighty (80g)ofRice was cooked with 1/3 volume of water in cooking vessel until soften and served with 30g of meat and 30ml stew**.**

7. Fried rice: Rice weighing 80g was cooked to soften as in (6 above) and fried with 15ml vegetable oil, 5g onion, 5g pepper, 5g tomatoes and 2 maggi cubes.

8. “Tuwon” rice: eighty (80g)Rice was cooked with 1/3 volume of water in cooking vessel until to soften and moulded into paste with wooden stirrer and served with 30ml soup.

9. Boiled cassava: peeled cassava tuber was sliced into reasonable size and 145g was cooked with 1/3 volume of water in cooking vessel until softened with 4g of salt to give taste and served with 30ml stew.

10. “Akpu”: Cassava tuber was peeled and soaked into water to ferment and fibres removed after crushing the fermented tubers. It was turned into sack and pressed to remove the fermented water. It was moulded into balls and parboiled and then pounded. This was repeated severally until smoothen dough is formed. It is eaten with 30ml stew mixed egusi soup,

11. “Eba”: hundred **(**100ml) ofBoiled water mixed with 134g of cassava Garri and turned, until paste is form and was served with 30ml egusi soup mixed with stew.

12. Soaked “garri”: sixty seven (67g)ofGarri was soaked in 100ml of water, 4 cubes of refine table sugar and 20g of groundnut was added and taken.

13. “Tuwon” maize: Maize husk was removed by pounding the maize using pestle and mortar. Subsequently is grinded to fine particle flour. 205g of Maize flour is moulded into paste with 160ml of boiled water; was served with 30ml of stew.

14. Maize “pap”: As in step (13) above but water is not seeped rather grinded into slurry and sieve, the residue removed. The filtrate is allowed to settle and decanted. Fifty (20g) of solid raw pap (slurry pre-prepared), 100ml

Food Forms	Serving Portion (g)
Boiled Yam	173
Pounded Yam	225
Fried Yam	175
Amala	280
Yam Porridge	173
White Rice	161
Fried Rice	161
Tuwon Rice	207
Boiled Cassava	134
Akpu	134
Eba	134
Soaked Garri	61
Tuwon Maize	203
Maize Pap	203
Massa	203
Tuwon Millet	192
Millet Pap	192
Fura	192
Sorghum Pap	190
Tuwon Sorghum	190
Fried Plantain	164
Ripe Plantain	156
Boiled Plantain	164
Boiled Water Yam	179
Water Yam Porridge	179
Boiled Sweet Potatoes	198
Sweet Potatoes Porridge	198
Fried Sweet Potatoes	198
Semovita	203
Tuwon Acha	173

50g Equivalent of CHO

of boiled water mixed with the slurry until semi solid is formed.

15. "Massa": as in step (14) above but water is not seeped. Pepper and onion was added and grinded into slurry. Yeast was added to the slurry to make it swell when frying. A designed moulder was used where the slurry was poured into the moulder containing hot vegetable oil. The Massa is turned until it slightly turned brown and was served with 30ml vegetable soup and meat.

16. "Tuwon" millet: same as in step (13).

17. Millet "pap": Same as in step (14).

18. "Fura": Millet is pounded to remove the husk, ginger added and grinded into fine particle flour. Little water is added to it, to aid moulding process into ball. The balls were parboiled in boiling water and finally pounded and rolled into balls. The rolled balls can be turned into slurry in water called Fura and taken mixed with animal milk or yoghurt.

19. Sorghum "pap": Same as in step (14)

20. "Tuwon" sorghum: Same as in step (13)

21. Fried plantain: Ripe plantain was peeled and sliced, it was fried in hot oil untilled it turned a little brownish. It is served with 30ml stew.

22. Ripe plantain: Same as step (21) but not fried rather eaten raw.

23. Boiled plantain: Same as step (22) but boiled unpeeled and served with stew.

24. Boiled water yam: peeled water yam sliced and cooked until softened with salt to add taste and served with stew (same as 1 above).

25.Water yam porridge: Peeled water yam was sliced and cooked until softened with salt, sliced tomato, red oil and maggi added to taste (same as 5 above).

26. Boiled sweet potatoes: Peeled sweet potatoes were slice and cooked until softened and was served with stew (same as 1 above).

27. Sweet potatoes porridge: Peeled potatoes was sliced and cooked until softened with salt, sliced tomato, red oil and maggi was served hot (same as 5 above).

28. Fried sweet potatoes: peeled potatoes were sliced and deeped fried until softened and served with stew (same as 3 above).

29. "Tuwon" semovita: Semovita flour was mixed in boiled water and turned until paste is formed. It was served with soup (same as 13 above).

30. "Tuwon" acha: forty (40g) of Acha grian was mixed in 80ml boiling water turned until paste is formed. It was served with 30ml stew.

Determination of GI of Carbohydrate Food Forms

The food varieties were prepared in the morning as indicated above. The fasting blood glucose level (FBG) test procedure of volunteers commenced at 08:00hrs in the morning after an overnight fast of 12 hours. Using food composition tables for local foods (FAO, 2012), weighed amounts of each food containing equivalent of 50g glucose (check Table 1) were measured. These were served with 30ml of the prepared stew(soup) composed of fresh pepper and tomato cooked with red palm oil and salt added to taste, with a piece of meat (beef only) of

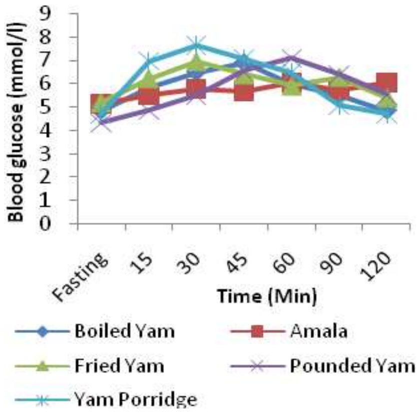

Figure 1. Postprandial Blood glucose levels of different yam food forms (Values are means n=3)

uniform size (35 g) and 350 ml of water. Blood samples were collected every 15 minutes interval for 2 hours.

Blood Test:

The blood samples from volunteer subjects were analyzed using Accu-chek glucometer to determine the FBG levels and recorded in mmol/dl.

GI was determined according to the guideline of Wolever *et al,* 2003. .Eighteen healthy volunteers, aged 16-24 years, with a mean body mass index (BMI) of 22.59 ±1.51 kg/m^2 were recruited to take part in the study. This accordance to GI Task Force, (2002) that suggests a minimum of 10-20 subjects to be recruited based on the willingness to comply with the protocol, inclusion and exclusion criteria. Each subject acts as his own control.

Calculation of Glycemic Index:

The glycemic index was calculated geometrically using the method described by FAO (1998) as the incremental area under the blood glucose response curve of a 50g carbohydrate portion of the test food (IAUC) expressed as a percent of the same amount of the carbohydrate from a standard food (IAUCS) taken by the same subject. Glucose-D was used as a reference food. The area under the curve is calculated as the incremental area under the blood glucose response curve. Where50g is the available glycemic Carbohydrate (known as Glucose reference test)

The GI for each food was calculated from the formula:

$$GI = \frac{IAUC}{IAUCS} x\ 100\%$$

Where GI= Glycemic index, IAUC= Incremental area under curve of test food, IAUCS= Incremental area under curve of standard (glucose-D).

The systemic classification of foods according to their glycemic responses was classified into ranges (Wolever *et al.*, 1991). The GI classifications are grouped into high (70-100%), moderate (50-70%) and low glycemic index (<50%) CHO foods.

Calculation of Glycemic Load (GL):

$$GL = \frac{GI \times Amount\ of\ CHO\ served\,(g)}{100}$$

Where GL = Glycemic load, GI = Glycemic Index, Amount = Food served in gram (g)

The systemic classification of foods according to their glycemic load was classified into ranges (Barclay *et al.*, 2005). The GI classifications are grouped into high (20+), moderate (11-29) and low glycemic load (0-10) CHO foods.

RESULT

Blood Glucose Response Curve of Thirty Nigerian Indigenous Food Forms

The postprandial blood glucose values (Figure 1) in subjects fed with different yam food forms. The highest peak was observed in the subjects who consumed yam porridge with 7.64mmol/l after 30min, while the lowest was recorded for those served with ‘amala’ with blood glucose concentration peak of 5.79mmol/l after 30mins of eating the meal.

Boiled water yam and water yam porridge had peaks of 8.14mmol/L and 8.36mmol/L after 30 and 15mins after ingestion respectively (Figure 2). The postprandial blood level declined steadily after 2-hours the meal was consumed.

The Postprandial blood glucose levels of different rice food forms including white rice, fried rice and ‘tuwon’

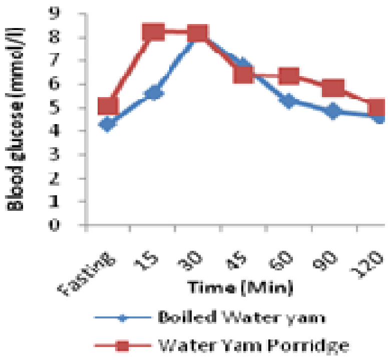

Figure 2. Postprandial Blood glucose levels of different water yam food forms (Values are means n=3).

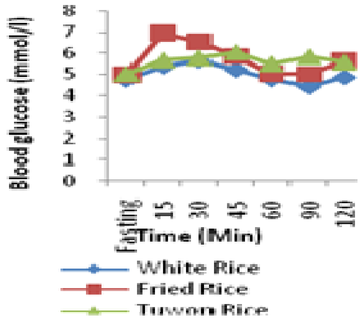

Figure 3. Postprandial Blood glucose levels of different rice food forms (Values are means n=3)

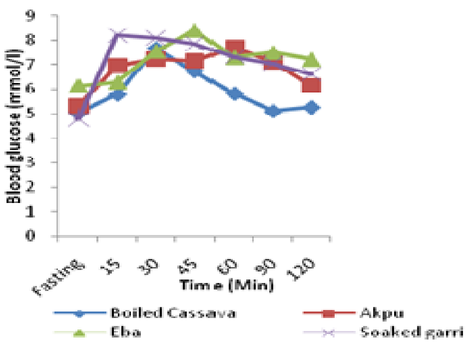

Figure 4 Postprandial Blood glucose levels of different Cassava food forms (Values are means n=3)

rice. Fried rice recorded the highest blood glucose peak of 6.97mmol/L after 15 mins of ingestion (Figure 3) while white rice had the least with 5.66mmol/L after 30 mins.

'Eba' recorded the highest peak of postprandial blood glucose of 8.40mmol/l after 45mins ingestion among cassava meal forms (Figure 4). Boiled cassava

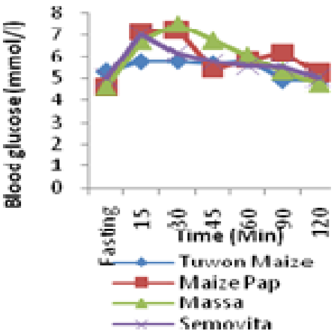

Figure 5. Postprandial Blood glucose levels of different Maize food forms (Values are means n=3)

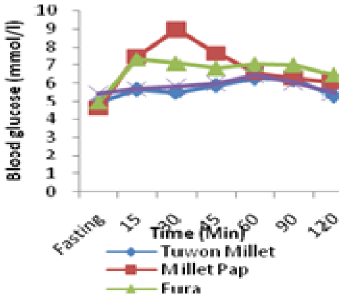

Figure 6. Postprandial Blood glucose levels of different Millet and acha food forms (Values are means n=3)

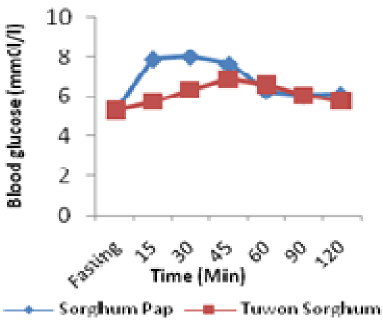

Figure 7. Postprandial Blood glucose levels of different sorghum food forms (Values are means n=3)

meal gave the least blood glucose level of 7.66mmol/l after 30mins of consumption.

Postprandial blood glucose curve for “massa” among the food forms made from maize had the highest peak of 7.49mmol/l after 30mins of consumption. In the same manner, the least peak in blood glucose curve for “tuwon” maize rose gradually to 5.81mmol/l after 60mins the subjects were served the meal (Figure 5).

Food forms from millet include “tuwon” millet, millet “pap” and “Fura “(Figure 6) with millet “pap” showing the highest blood glucose with the peak of 8.96mmol/l after 30mins while “tuwon” millet recorded the least peak of 6.27mmol/l, after 1-hour consumption. “Tuwon” acha being a different food form entirely from millet had a steady rise in blood glucose level of 6.44mmol/l after 1-hour of consumption.

Postprandial glucose curves for sorghum pap and tuwon sorghum are shown in Figure 7. It shows a rapid blood glucose increase for subjects served with sorghum “pap” with the highest peak of 8.01mmol/L after 30

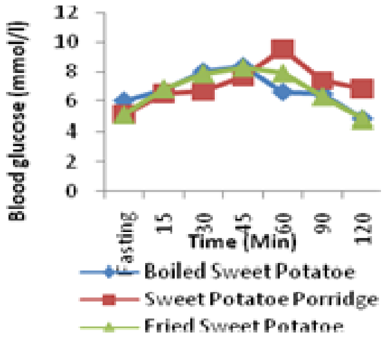

Figure 9. Postprandial Blood glucose levels of different sweet potatoes food forms (values are means n=3).

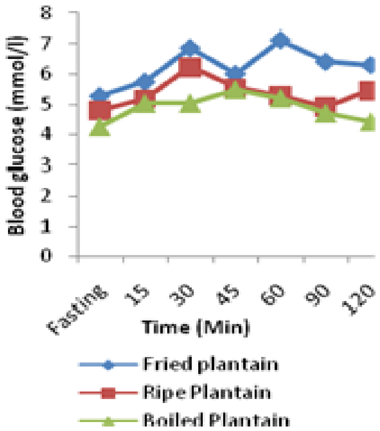

Figure 8. Postprandial Blood glucose levels of different plantain food forms (Values are means n=3).

minutes of ingestion. “Tuwon” sorghum had the least peak of 6.90mmol/l after 45mins of ingestion.

Plantains meals are consumed in different forms as fried; boiled or ripped plantain (Figure 8). The fried and ripped plantain gave two peaks of blood glucose, 6.88mmol/l and 7.14mmol/l at time 30 and 60 mins respectively. Whereas boiled plantain recorded the least peak of 5.49mmol/l after 45mins it was served.

Sweet potatoes were consumed in the form of boiled, fried and porridge and the result of the postprandial glucose (Figure 9) with fried sweet potatoes giving the lowest peak of 8.27mmol/L after 45mins. The sweet potatoes porridge had highest peak of 9.55mmol/L after 60mins of ingestion.

Glycemic index and Glycemic load classification of thirty Nigerian indigenous staple foods were calculated for their glycemic index, 33% of the food forms are high glycemic index foods which elicit fast postprandial blood glucose level, and 23.3% were classified as moderate glycemic index foods and 43.7% of the food forms are classified as low glycemic index (Table 2). The glycemic loads of these food forms were slightly different from the glycemic index of food (Table 3), due to the serving portion of the carbohydrate food. From the glycemic load classification, 26.67% of the food forms were high glycemic load food. A good number of the food forms studied were moderate glycemic load foods (53.33%), whereas 20% of the food forms were classified as low glycemic load foods.

DISCUSSION

Blood Glucose Concentration of Thirty Nigerian Indigenous Foods.

A greater percentage of Nigerian indigenous food forms fall into the moderate and low GI category, the variations in GI diets is due to amylose content and form in which the food was prepared. Carbohydrate foods have been evaluated, and found to have different glycemic values depending on the chemical structure of the foodstuffs,

Table 2. Glycemic index classification of thirty Nigeria staple food forms

HGI	MGI	LGI
Boiled Yam	Tuwon Rice	Pounded Yam
Fried Yam	Akpu	Amala
Yam Porridge	Soaked Garri	White Rice
Fried Rice	Tuwon Sorghum	Eba
Boiled Cassava	Ripe Plantain	Tuwon Maize
Maize Pap	Boiled Water Yam	Massa
Sorghum Pap	Boiled Sweet Potatoes	Tuwon Millet
Sweet Potatoes	Porridge	Millet Pap
Fried Sweet Potatoes		Fura
Semovita		Fried Plantain
		Boiled Plantain
		Water Yam Porridge
		Tuwon Acha

High Glycemic Index (HGI), Moderate Glycemic Index (MGI) and Low Glycemic Index (LGI)

Table 3. Glycemic Load classification of thirty Nigeria staple food forms

HGL	MGL	LGL
Boiled Yam	Pounded Yam	Amala
Fried Yam	White Rice	Tuwon Maize
Yam Porridge	Tuwon Rice	Massa
Fried Rice	Eba	Tuwon Millet
Boiled Cassava	Millet Pap	Water Yam Porridge
Akpu	Fura	Tuwon Acha
Soaked Garri	Sorghum Pap	
Maize Pap	Fried Plantain	
Ripe plantain		
Boiled Plantain		
Boiled Water Yam		
Boiled Sweet Potatoes		
Sweet Potatoes Porridge		
Fried Sweet Potatoes		
Sorghum tuwo		
Semovita		

High Glycemic Load **(HGL),** Moderate Glycemic Load **(MGL) and** Low Glycemic Load **(LGL)**

particle size and the portion sizes served (Brouns *et al*., 2005; Vonk *et al*., 2000). Digestion and absorption of the various foodstuffs depends on structural differences of the food molecule and the rate at which amylase enzyme hydrolyzed glucose molecules and their absorption into the blood (Omoregie & Osagie, 2008).

Yam porridge a delicacy consumed by the Nigerian indigenes, rapidly increased blood glucose level to reach its highest peak after 30 minutes of eating the meal. Meaning the food is rapidly digested and absorbed into the blood. Alteration of the physical form of carbohydrate changes the postprandial glucose level and insulin response in the blood to high peak at a short pace (O'Dea *et al*., 1980; O'Dea *et al*., 1981; Wong & O'Dea, 1983). Pounded yam slowly raised blood glucose level after 60 minutes of ingestion. Among all yam food forms, "amala" consistently maintained low blood glucose over long period of 60 minutes (Figure 1). Preparation of yam flour ('elubo') passed through stages and sun-drying leading to loss of water content with a progressive re-association of the starch molecules (retro-gradation) (FAO/WHO, 1998). The re-association of starch molecules in "elubo" would decrease the digestibility (Pi-sunyer, 2002). It can be concluded that "amala" consistently maintained low blood glucose for a long period, amala can be a preferred food form of yam for weight management and other health benefits such as in management of diabetes, cancer etc.

Boiled water yam and water yam porridge constitute one of the food forms consumed by Nigerians. Water yam porridge showed highest peak after 15 minutes. Boiled water yam showed low rise in blood glucose and peak after 30 minutes. Water yam has been found to be suitable for diabetic patient, because the glucose molecule is slowly absorbed into the blood stream, and effective for the management of insulin secretion of type 2 diabetes (Figure 2).

Rice is a major staple in West Africa with an annual consumption rate of 4% (Janette, 1985). Rice and its various food forms shown in Figure 3 constitute the most consumed class of food in the world today (Fernandez *et al.,* 2005). White, fried and "tuwon" rice are the various rice forms commonly consumed in Nigeria (Fernandez *et al*. 2005). Fried rice is rapidly digested and glucose molecule absorbed into the blood, and peaked after 15mins of ingestion. Fried rice elicited more rapid blood glucose levels than white or tuwon rice. The cooking method of fried and "tuwon" rice increases the surface area of the food form for hydrolytic activities of amylase(Janette, 1985). White rice and "tuwon" rice consistently maintained low blood glucose to peak after 30mins and 45mins respectively. White and tuwon rice are moderate glycemic load foods, these food forms are slowly absorbed into the bloodstream because of their structural forms and reduced surface area the food possibly not masticated to be made available for enzyme activity. The high amylose to low amylopectin content ratio cannot be harnessed as tools in weight management regiment. The study thus showed that the low blood glucose response level of the food form may effectively manage metabolic diseases(Ludwig, 2002).

The blood glucose response curve for cassava related foods, such as soaked garri showed a sharp rise in blood glucose which had highest peak after 15minutes and gradually decline (Figure 4), whereas boiled cassava showed highest blood glucose level after 30 minutes of ingestion. Cassava tuber contain high percent of amylose, amylase easily hydrolyzed the polysaccharides into glucose and dextrins, making the glucose molecules more readily absorbed into the blood, hence referred to as rapidly absorbed glucose (RAG) (Gulhooly *et al.*, 2007). "Akpu" steadily increased blood glucose level after 60 minutes, referred as moderate glycemic load food. The delay in the rise of blood glucose in cassava food forms as a result of high fiber and cyanide content.

"Massa" was slowly digested and liberates glucose into the blood after 30 minutes blood glucose concentration of reaching its peak and decline steadily (Figure 5), referred as slowly absorbed glucose (SAG). "Tuwon" maize showed consistent low blood glucose level and reach it peak after 60 minutes and declined steadily after 1hour, it can be used to manage weight gain (Astrup, 2001).

Millet "pap" showed highest blood glucose level after 30 minutes and steadily declined with time. "Tuwon" millet steadily raises blood glucose which peaked after 60 minutes of ingestion. "Tuwon" acha showed low peak of blood glucose after 60 minutes. Fura showed highest peak after 15 minutes and steadily maintained low blood glucose level. (Figure 6). The low peak and low glucose level of the food forms are thus recommended as useful in the management of type II diabetes and weight control. (Astrup, 2001).

Sorghum "pap" showed highest blood glucose level after 15 minutes of ingestion (Figure 7). The sorghum "pap" elicited rapid blood glucose, and because of its rapid glucose level in the blood it can induce body weight and other health implications like coronary heart diseases and obesity (Ludwig *et al.,* 2002). Same phenomena observed for 'tuwon' sorghum.

Fried and boiled plantain both maintained low blood glucose peaked after 60 and 45 minutes respectively (Figure 8). These food forms help in regulating blood glucose level and insulin secreted. Boiled plantain is a low GI food form because the unpeeled plantain absorbed water and due to sufficient heat that fully gelatinize the starch granules, thus making it resistant for amylase digestion and release of glucose into the bloodstream (Ramdath *et al*., 2004).

Sweet potatoes porridge showed highest peak after 60 minutes of ingestion and Fried potatoes slowly raises the blood glucose and peaked after 45 minutes. Sweet potatoes porridge and fried potatoes (Figure 9) are easily digested and therefore have higher GIs and GLs than foods containing starch granules that are less gelatinized (Wolever *et al*., 1994).

"Amala", "akpu", "tuwon" maize, "tuwon" millet, "tuwon" "acha", pounded yam, water yam porridge, white rice, "massa" and fried plantain are food forms that raise blood glucose slowly, and are described as low GI/GL diets which can be important in the management of hyperglycemia and other related metabolic diseases. These food forms have a potential role in dietary control strategies to prevent and also in the treatment of diabetes and obesity (Anderson *et al*., 1991; Oboh *et al*., 2010). Trout *et al*., (1993) observed that the food forms influence the manner in which the food is digested and absorbed into the blood.

Food forms like boiled yam, fried yam, yam porridge, fried rice, boiled potatoes, fried potatoes, potatoes porridge, boiled cassava and maize pap are classified both as high GI and GL and cause an uncontrolled rise in blood glucose level. As a result, counter-regulatory hormones like insulin are secreted to regulate blood sugar level.

The health implications of the high GL foods cause a fast and short - lived rise in blood sugar, with the consequence that one is lacking in energy and results to hungry sensation within a short time (Ludwig, 2002), thus the desire to eat will increase. High GL foods results to gain weight and obese, it trigger diabetes in individuals that are at risk to the disease, or worsen the management of the disease (Gilberston *et al*., 2001).The development of cancer and cardiovascular disease (CVD) has been reported to be linked to high G.I foods (Ludwig, 2002).

Type II diabetes is associated with insulin insensitivity result from elevated blood sugar levels and increased insulin demand; thus over burdening the ability of the pancreas to produce insulin. Reports by Salmeron *et al.*, (1997) have indicated a positive correlation between high GI/GL and risk of type II diabetes. The regular consumption of high glycemic load foods will lead to health risk implications in diseases like the heart diseases due to insulin resistant syndrome called metabolic syndrome X (Ludwig, 2003). High blood glucose level is associated with increased blood pressure, blood clot formation and reduced endothelial dependent blood flow (Ludwig, 2003).

The results of the present study could serve as a guide to the dietitians and researchers in the field of nutrition to appropriate dietary recommendations to patients who request specific food calories.

The knowledge of GI and GL of Nigerian food forms could help to control and prevent hyperglycemia. The GI and GL table provide a data base for effective use in diet management where it is crucial to control blood glucose levels. The findings of this study are useful for health care providers and nutritionists in metabolic disease Education.

CONCLUSION

It can be concluded that greater percentage of the studied Nigerian food forms are moderate and low glycemic load foods which are serve for consumption. Whereas the high glycemic load diets that constitute less percentage of Nigerian food forms, induced oxidative stress as result of consuming high glycemic foods.

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