Journal of Diabetes and Metabolism

Emaleku, J Diabetes Metab 2017, 8:12
DOI: 10.4172/2155-6156.1000777

Research Article Open Access

Comparative Glycemic Index and Glycemic Load of Local Pounded Yam and Instant Pounded Yam Flours Consumed with *Telfairia Occidentalis* (Ugwu) Soup in Test Human Subjects

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Received date: December 01, 2017; **Accepted date:** December 12, 2017; **Published date:** December 17, 2017

Abstract

Aim: The concept of glycemic index (GI) was introduced to classify carbohydrates and carbohydrate-rich diets, which are major staple foods in Nigeria. This study evaluates the glycemic index and glycemic load (GL) of local pounded yam and four instant pounded yam flours consumed with *Telfairia occidentalis* soup in test human subjects.

Materials and Methods: Thirty human subjects were fed with D- glucose on the first day of the experiment and the test meals; local pounded yam (LPY), local pounded yam with *Telfairia occidentalis* soup (LPYTOS), *Ayoola poundo* yam with *Telfairia occidentalis* soup (APYTOS), *Endy's poundo* yam with *Telfairia occidentalis* soup (EPYTOS), Iyan poundo yam with *Telfairia occidentalis* soup (IPYTOS) and Ola-Ola poundo yam with *Telfairia occidentalis* soup (OPYTOS) in the 2nd, 3rd, 4th, 5th, 6th and 7th day respectively after 12 h of overnight fasting. The blood glucose levels were determined at 30 min interval for 2 h, and were used to determine the incremental areas under the curves (IUACs) for the various meals, which in turn were used to determine their GIs, while GLs were calculated from GIs.

Results: The GIs and GLs (46.00 ± 2.08%; 23.33 ± 1.20%), (48.67 ± 0.88; 25.00 ± 0.58) and (50.33 ± 1.45%; 26.00 ± 0.58%) of APYTOS, IPYTOS and EPYTOS respectively were significantly lesser than the GI and GL of the other meals.

Conclusion: APYTOS, IPYTOS and EPYTOS are low GI foods with high GL values, while LPY is a moderate GI food with high GL also although, its' GL is higher.

Keywords: Glycemic index; Glycemic load; Instant pounded yam flour; Local pounded yam

Introduction

Pounded yam is a major staple food consumed across the nation (Nigeria), most especially in the south west region like Ado-Ekiti, Ondo, Oyo etc. and some parts of north and south of the country. It is eaten with different soups, of which vegetable soup is one. It is a delicacy people like to eat however, its toilsome preparation is a major setback. Its pounding is strenuous [1] i.e. tedious, menial and energy exhausting. The need to therefore have a convenience food that reduced this drudgery and strenuous activities associated with the preparations of local pounded yam (LPY) led to the production of the various brands of instant (industrial) pounded yam flours (IPYFs) that are now available in markets [2,3]. The limiting factor (rigor of pounding) encountered by the lovers of LPY that might have hindered its frequent consumption by people had been greatly reduced with the production of IPYFs [2]. But unfortunately, the glycemic index (GI) and glycemic load (GL) of many Nigerian foods including IPYFs are not yet established or defined [4,5] despite their popular consumption.

The concept of GI was introduced as a means of classifying various carbohydrate and carbohydrate-rich diets. This classification is based on the effects of diets on postprandial blood glucose level, because different carbohydrate containing foods have different blood glucose responses [6,7]. GI refers to the ranking of foods that have the ability to raise blood glucose concentrations, relative to a standard food (glucose) [6]. While the concept of GL was developed by scientists to simultaneously describe the quality (GI) and quantity of carbohydrate in a serving meal more so that, the amount of carbohydrate contained in a served food affects blood glucose concentrations and insulin responses [8]. GL of food is a number that estimates how much the food will raise a person's blood glucose level after eating it [9]. It accounts for the amount of carbohydrate in food and how much each gram of carbohydrate in the food raises blood glucose levels. It estimates the impact of carbohydrate consumption using GI, taking the amount of carbohydrate consumed into consideration. It is GI-weighted measure of carbohydrate content [10].

Moreover, GI is defined for each type of food; whereas GL can be calculated for any size serving of a food, an entire meal or an entire day's meals. GL is therefore a better indicator than GI on how carbohydrate food would affect blood glucose [11]. It is a significant factor alongside GI in dietary programs that target metabolic syndrome, insulin resistance and weight loss; and studies have shown that sustained spikes in blood sugar and insulin levels may lead to increased diabetes risk [12]. Epidemiological and dietary intervention studies suggest that a low GI food is beneficial for blood glucose control, while the consumption of high GI or GL foods is hypothesized to contribute to insulin resistance, which is associated with increased risk of diabetes mellitus (DM), cardiovascular diseases (CVDs), obesity and some cancers [13]. According to Willet et al. [14], the consumption of high GI and GL diets for several years might result in higher postprandial blood glucose concentrations and excessive insulin secretion, which might contribute to loss of insulin-secreting function of the beta cells thereby leading to irreversible type 2 DM.

Therefore, this study investigates the glycemic index and glycemic load of local pounded yam and instant pounded yam flours consumed with *Telfairia occidentalis* (ugwu) soup in test human subjects. This is necessary because, evidence from prospective studies had linked GI and GL of foods to the upsurge, incidence and prevalence of some chronic diseases such as DM; most especially type 2 DM [15], CVDs, cancer [16] etc. currently rampaging man. It is believed that the knowledge of GI and GL of these meals would be essential for rational advice of their consumption by the teeming population of Nigeria.

Materials and Methods

Experimental subjects

Thirty human subjects from Adekunle Ajasin University, Akungba-Akoko, Ondo State, Nigeria, between the ages of 22-24 years, with body mass index (BMI) of 23.13 ± 2.53 kg/m^2 were used for this study after obtaining approval for the study from the Health Research Ethical Committee of the Federal Medical Centre, Owo, Ondo State. Subjects signed a written agreement in addition to their verbal interest and willingness to participate in this research work after consultation. They were clinically normal, non-smokers, non-alcoholics, non-hyperlipidemia and non-diabetic subjects. They followed the study protocols (rules) without any prejudice to their social and religious status, and remained within the confinement of the experimental area.

Food stuff

Fresh sample of *Telfairia occidentalis* vegetable, white yam (*Dioscorea rotundata*), Ayoola, Iyan, Olaola and Endy's poundo yam flours and cooking equipment cum condiments were purchased at Ibaka-Akungba local market, Ondo State, Nigeria, and were certified hygienic for human consumption. The veggie and yam were identified and authenticated by Dr. O A Obembe, a senior lecturer in the department of Plant Science and Biotechnology of Adekunle Ajasin University, Akungba Akoko, Ondo State.

Food stuff preparation

The fresh leafy vegetable, whose edible portion has been separated from its inedible parts, was rinsed in clean water, allowed to drain and subsequently shredded into slices of almost equal sizes. The desired quantity of the vegetable cum condiments such as 20 g onions, 40 g pepper (atarodo), 60 g locust bean, 1 g of salt and 120 ml palm oil was steamed for about 10 min. The local pounded yam (LPY) was prepared by peeling and slicing the yam, and was cooked until softened, and later pounded in a mortar using a pestle to smoothen the dough (solid paste), while Ayoola, Iyan, Olaola and Endy's poundo yam flours were respectively prepared in hot water by continuous stirring until they became smooth solid pastes, and 50 g of D-glucose (DG) used as control meal was dissolved in 100 ml of water.

Proximate composition of foods

The proximate composition of the food samples i.e. solid pastes of LPY, Ayoola poundo yam (APY), Iyan poundo yam (IPY), Olaola poundo yam (OPY) and Endy's poundo yam (EPY), and *Telfairia occidentalis* soup (TOS) were determined using conventional standard methods of analysis of Association of Official Analytical Chemists, AOAC [17].

Feeding of human subjects

Thirty human subjects that served as both control and test groups were fed water-dissolved DG on the first day of the experiment, and the test meals; LPY, LPY with TOS (LPYTOS), APY with TOS (APYTOS), EPY with TOS (EPYTOS), IPY with TOS (IPYTOS) and OPY with TOS (OPYTOS) in the 2nd, 3rd, 4th, 5th, 6th and 7th day respectively after 12 h of overnight fasting. **Note:** The various quantities of these solid pastes containing 50 g available carbohydrate were given to the human subjects.

Blood glucose determination

The blood glucose levels of the human subjects were determined using portable glucometer; once before meals (pre-prandial blood glucose) and four times for two hours at 30 min interval after meals (postprandial blood glucose).

Glycemic index determination

Blood glucose concentrations of the human subjects were used to plot blood glucose response curves graph, which in turn was used to calculate the GI of the foods. A modified version of Wolever et al. [18] method introduced by Emaleku in 2013 was used to determine the GI of each meal; DG, LPY, local pounded yam with *Telfairia occidentalis* soup (LPYTOS), Ayoola poundo yam with *Telfairia occidentalis* soup (APYTOS), Endy's poundo yam with *Telfairia occidentalis* soup (EPYTOS), Iyan poundo yam with *Telfairia occidentalis* soup (IPYTOS) and Olaola poundo yam with *Telfairia occidentalis* soup (OPYTOS) from the graph (Figure 1). The incremental areas under curves (IUACs) of the various meals used to determine GI was gotten by summing up the surface triangles and rectangles under the blood glucose response curve graph [19]. The GI of the test meals was then gotten by dividing the IAUC of the test meals by IUAC of the standard meal (DG) multiply by 100.

For example: GI=IUAC of EPYTOS ÷ IUAC of standard meal (glucose) × 100%.

Citation: Emaleku SA (2017) Comparative Glycemic Index and Glycemic Load of Local Pounded Yam and Instant Pounded Yam Flours Consumed with *Telfairia Occidentalis* (Ugwu) Soup in Test Human Subjects. J Diabetes Metab 8: 777. doi:10.4172/2155-6156.1000777

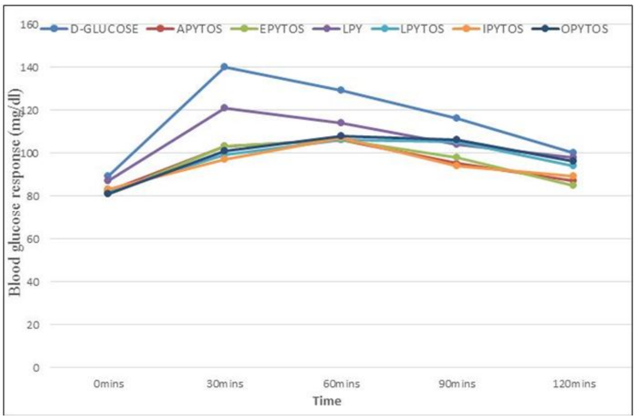

Figure 1: Mean blood glucose response curve of human subjects after meals' consumption.

Glycemic load determination

It was calculated by dividing GI of the meal by 100 and multiplies it by the number of available carbohydrate in the meal consumed.

Mathematical representation is as follows: GL=GI/100 × available carbohydrate (50 g)

Statistical analysis

Proximate composition, GI and GL data were statistically evaluated with SAS version 8 software using one-way analysis of variance (ANOVA) with Duncan Multiple Range Test and Pearson Correlation, and the results were expressed as mean ± standard error mean (SEM). F-test and T-test at 95 (i.e. 0.05) level of significance was used to assess significant difference. A value of P<0.05 was considered to indicate significant difference between and within groups.

Results

Table 1 result showed that; LPY had significantly higher protein content (6.63 ± 0.07%) than the four IPYFs however; the protein contents (5.60 ± 0.25% and 5.16 ± 0.27%) of APY and OPY respectively were significantly higher than 4.25 ± 0.25% and 4.18 ± 0.26% of IPY and EPY respectively. Moreover, the fiber contents (0.74 ± 0.10%; 0.57 ± 0.07% and 0.51 ± 0.09%) of APY, EPY and LPY respectively were significantly higher than 0.41 ± 0.05% and 0.24 ± 0.03% of OPY and IPY respectively.

Sample ID	Moisture (%)	Ash (%)	Fat (%)	Fiber (%)	Protein (%)	Carbohydrate (%)
APY	50.36 ± 0.25^{E}	0.49 ± 0.04^{CC}	2.92 ± 0.19^{CC}	0.74 ± 0.10^{AA}	5.60 ± 0.25^{BB}	39.89 ± 0.32^{AA}
EPY	58.31 ± 0.28^{A}	0.45 ± 0.05^{CC}	3.22 ± 0.14^{CC}	0.57 ± 0.07^{BA}	4.18 ± 0.26^{CC}	33.27 ± 0.13^{CC}
IPY	55.35 ± 0.41^{C}	1.11 ± 0.03^{BA}	4.43 ± 0.25^{AA}	0.24 ± 0.03^{CC}	4.25 ± 0.25^{CC}	34.62 ± 0.18^{BB}
OPY	56.80 ± 0.27^{B}	1.01 ± 0.08^{BB}	3.41 ± 0.04^{CB}	0.41 ± 0.05^{CB}	5.16 ± 0.27^{BB}	33.20 ± 0.10^{CC}
LPY	53.71 ± 0.26^{D}	1.24 ± 0.11^{AA}	4.15 ± 0.42^{BA}	0.51 ± 0.09^{BA}	6.63 ± 0.07^{AA}	33.76 ± 0.70^{CB}
TOS	63.04 ± 0.25	1.87 ± 0.17	12.48 ± 0.04	4.99 ± 0.21	16.61 ± 0.27	1.61 ± 0.35

KEY: APY-Ayoola poundo yam; EPY-Endy's poundo yam; IPY-Iyan poundo yam; OPY-Olaola poundo yam and LPY-Local pounded yam; TOS-*Telfaria occidentalis* soup. NOTE: These results are presented in mean ± SEM. At (p<0.05) significance, values with the same notation (s) do not differ significantly, but those with different notation (s) do.

Table 1: Proximate composition of food samples.

Furthermore, the fat contents (4.43 ± 0.25% and 4.15 ± 0.42%) and ash contents (1.11 ± 0.03% and 1.24 ± 0.11%) of IPY and LPY respectively were significantly higher than the fat contents (3.22 ± 0.14% and 2.92 ± 0.19%) and ash contents (0.45 ± 0.05% and 0.49 ± 0.04%) of EPY and APY respectively, but were not significantly higher than 3.41 ± 0.04% and 1.01 ± 0.08% of OPY's fat and ash respectively, except IPY's fat that was significantly higher than OPY's fat. More also, the moisture contents of the pounded yams differed significantly from one another, with EPY and APY having the highest (58.31 ± 0.28%) and lowest (50.36 ± 0.25%) contents respectively. In addition, APY's carbohydrate content (39.89 ± 0.32%) was significantly higher than 34.62 ± 0.18% of IPY, 33.76 ± 0.70% of LPY, 33.27 ± 0.13% of EPY and 33.20 ± 0.10% of OPY; and IPY's carbohydrate did not differ significantly from that of LPY, neither did LPY's carbohydrate differs significantly from EPY's carbohydrate. It is noteworthy that Olaoye and Oyewole [1] reported higher crude fat (4.79%) and protein (6.63%) for an unnamed instant (industrial) pounded yam flours (IPYF), while Fasanmade and Anyakudo [4] reported lesser crude fat (0.4%) and protein (3.40%) contents for another unnamed IPYF.

Parameters	Moisture	Ash	Fat	Fiber	Protein	Carbohydrate
Moisture	1	0.03816	0.1103	-0.4071	-0.57480^{S}	-0.86339^{S}
Ash	0.03816	1	0.71457^{S}	-0.66401^{S}	0.37632	-0.44968

Fat	0.1103	0.71457^{S}	1	-0.63568^{S}	0.01661	-0.43028
Fiber	-0.4071	-0.66401^{S}	-0.63568^{S}	1	0.29921	0.50262
Protein	-0.57480^{S}	0.37632	0.01661	0.29921	1	0.16615
Carbohydrate	-0.86339^{S}	-0.44968	-0.43028	0.50262	0.16615	1
Note: The superscript S means differ significantly at (P<0.05). Comparison is down and across columns						

Table 2: Relationship between proximate composition parameters.

Table 2 showed that moisture had significantly negative correlation with protein, carbohydrate, but non-significantly negative correlation with fiber, and had non-significantly positive relationship with ash and fat. It further revealed that; ash and fat are significantly and positively correlated, but were negatively and significantly correlated with fiber.

Meals	Glycemic index (%)	Glycemic load
D-Glucose (DG)	100.00 ± 0.00^{AA}	50.00 ± 0.00^{AA}
LPY	68.33 ± 0.33^{BB}	34.67 ± 0.33^{BB}
LPYTOS	60.33 ± 1.86^{CC}	31.67 ± 1.20^{CC}
APYTOS	46.00 ± 2.08^{ED}	23.33 ± 1.20^{DD}
EPYTOS	50.33 ± 1.45^{DD}	$26.000.58^{DD}$
IPYTOS	48.67 ± 0.88^{DD}	25.00 ± 0.58^{DD}
OPYTOS	69.67 ± 1.45^{BB}	$35.670.88^{BB}$
Note: These results are presented in mean ± SEM. At (P<0.05) significance values with the same notations do not differ significantly, but those with different notations do.		

Table 3: Glycemic index and glycemic load of pounded yam solid pastes consumed with Telfaria occidentalis soup (TOS).

Table 3 results showed that APYTOS, IPYTOS and EPYTOS had significantly lesser GIs (46.00 ± 2.08%; 48.67 ± 0.88 and 50.33 ± 1.45%) and GLs (23.33 ± 1.20; 25.00 ± 0.58 and 26.00 ± 0.58) respectively than LPYTOS, LPY, OPYTOS and DG's GIs (60.33 ± 1.86%; 68.33 ± 0.33%; 69.67 ± 1.45% and 100.00 ± 0.00%) and GLs (31.67 ± 1.20; 34.67 ± 0.33; 35.67 ± 0.88 and 50.00 ± 0.00) respectively. However, there were no significant differences between the GIs of APYTOS, IPYTOS and EPYTOS, just as there were no significant differences between their GLs. In line with one of these findings; Fasanmade and Anyakudo [4] reported the GI of 49.80% for an instant pounded yam consumed with *Corchorus olitorious* (ewedu) soup, a value that falls within the range of 46.00-50.33% GI values found for APYTOS, IPYTOS and EPYTOS. Additionally, the results showed that; consumption of LPY with TOS (LPYTOS) significantly reduced GI and GL when compared with LPY consumption without TOS.

Figure 1 revealed that APYTOS, IPYTOS and EPYTOS had reduced postprandial glucose peaks (at 90 min) and lower IAUCs than LPYTOS, OPYTOS, LPY and DG. This is in accordance with the findings of Wolever et al. [18] and Freeman [20] about low and high GI foods. It is also in consistent with Brand-Miller et al. [21] findings about blood glucose response curves for low and high foods. The figure further showed that the consumption of LPYTOS caused reduction in postprandial glucose peak and IAUC compared with LPY consumption.

Discussion

The highest protein content cum high fat and fiber contents of LPY are good nutritional qualities that could act as driving force for its consumption, because they would definitely have their health-benefiting advantages in addition to being nutritive. The high fat and protein contents of LPY and the good proportions of these nutrients in APYTOS, IPYTOS, OPYTOS and EPYTOS suggest that; they could reduce glycemic response rate, and could consequently have low GI. According to Henry et al. [22], high fat has the ability to delay gastric emptying, which in turn slow down digestion and absorption of glucose, and thereby prevents eating binge (overeating) that could on long term results to insulin resistance (a metabolic deranged condition) caused by sustained insulin spike. While according to Hätönen et al. [23], high protein level would produce greater gastric inhibitory peptide (GIP) (known as glucose-dependent insulin tropic peptide); an inhibitory hormone that induces insulin secretion and prompts insulin responses, which results in lower postprandial peak and reduced glycemic response due to its enhanced insulin activities. Fat may also affect the interaction of plasma glucose, insulin and GIP [24]. Owen and Wolever [24] found that; eating 50 g available carbohydrate of white bread (high GI) with high quantity (40 g) of non-hydrogenated margarine fat significantly reduced IAUC and blood glucose response by 30%.

Moreover, the significantly high fiber content of APYTOS, EPYTOS and LPY further underline their importance as sources of health benefiting nutrients in addition to being rich in carbohydrate. Fibers in foods are plant non-digestible carbohydrate and lignin, which have been shown to have health benefits [25], and research evidence abound that link dietary and functional fibers to positive health outcomes. According to Oko et al. [26] and Turner and Lupton [25], the known health benefits of increased dietary fiber in foods include; slow glucose absorption, improved insulin sensitivity, reduction in cholesterol and LDL-C levels; as well as reduced incidence of type 2 DM, coronary heart diseases, cancers etc.

Considering Table 2, the negative significant correlation of moisture with protein and carbohydrate cum non-significant negative correlation with fiber, and non-significant positive relationship with ash and fat implies that; increase in moisture content would bring about concomitant decrease in protein, carbohydrate and fiber contents (although, the extent of decrease in fiber would be less), while there would be concurrent increase in ash and fat contents although, in a lesser extent. This seems to be correct critically considering Table 1. For example, EPY with the highest moisture content had the least protein and one of the least carbohydrate contents cum moderately high fat. Therefore, meals with high moisture content are most likely to have low protein and carbohydrate contents with average fat contents. Thus, moisture content is inversely proportional to protein and carbohydrate contents, but less directly proportional to fat.

However, a number of studies had revealed that GIs of foods commonly consumed in China and UK are not affected by protein and fat contents [27,28]. This might be correct because, the GIs and GLs of LPY (68.33%; 34.67) and LPYTOS (60.33%; 31.67) were still significantly higher than that of APYTOS (46.00%; 23.33), IPYTOS (48.67%; 25.00) and EPYAH (50.33%; 26.00) despite the significant high protein cum high fat and fiber contents of LPY shown in Table 1. In consistent with this position, Al Dhaheri et al. [29] reported that; Gurus with high fiber (4.11 ± 0.73 g), protein (8.76 ± 0.16 g) and fat (7.71 ± 0.90 g) contents still had high GI value of 71.7% due to its cooking method, and findings about LPY tend to be in consonance with their findings. According to Aston et al. [30], GI does not just measure the carbohydrate absorption in the small intestine directly, but also indicates the effect of other factors in the foods that can influence the rate of carbohydrate absorption in small intestine, which would in turn influence GI. It is therefore reasonable to say that the significant differences in GI and GL values of these solid pastes consumed with the same veggie soup would be more due to other factors like processing and cooking methods, yam's cultivars etc. than just proximate composition quantification.

During cooking, water and heat expand the starch granules to varying degrees, which brings about swollenness of starch foods to breaking point as in boiled yam used for LPY and making the food to be more easily digested, and resultantly high GI [31] and concurrently high GL. High temperature and increased cooking time in a large quantity of water as occurred in LPY preparation are associated with increased starch gelatinization and degree of digestibility, as well as increased blood glucose levels [32], which would in turn lead to high GI and GL. Pounding of the cooked yam with pestle in a mortar with intermittent addition of water makes the yam softer and finer thereby increasing its surface area upon which digestive enzymes would act, and thus more rapid absorption of glucose [1] that consequently resulted to the high GI of LPY, and high GL since it depends on GI. Conversely, instant pounded yam flours (IPYFs) except OPYTOS with almost high GI (69.67%) had lower GI and concurrent lower GL (although the GLs are high based on international classification that classified ≥ 20 as high GL) than LPY, LPYTOS and DG probably because, they were reconstituted into smooth solid pastes by stirring in hot water with lesser cooking time, no intermittent addition of water and without pounding. Alinnor and Akalezi [33] reported 40.61% of carbohydrate for uncooked white yam and 33.76% when it was cooked and used to make LPY. Similarly, Al Dhaheri et al. [29] found that cooking method's effect played role in increasing food's moisture content. Using biochemical reasoning, differences would consequently occur in the rate of release of glucose into the body as well as in blood glucose levels that would likely cause GI to vary and this further establish the potential effects of processing and cooking methods on GI and concurrently GL via proximate composition.

However, the nearly-high GI and high GL of OPYTOS prepared in similar manner like the other IPYFs suggest that there is/are more to the observed significant differences in the results. For instance, differences in manufacturing company's processing efficiency and operational processes (selection, peeling, washing, cutting, parboiling) involved in the production of IPYFs [3], which has the disadvantage of losing calcium, β-carotene, ascorbic acid etc. [34] could be a reason. Also, it is well reported that increased amylose in meal would decrease postprandial glucose level and insulin responses in people with either normal glucose tolerance or impaired glucose tolerance [35], and consequently enhance low GI. Brand-Miller et al. [31], found higher ratio of amylose to amylopectin in basmati rice than in instant rice, and consequently basmati rice had lower GI (58%) than instant rice (87%). It is therefore possible that APYTOS, EPYTOS and IPYTOS have higher ratio of amylose to amylopectin than OPYTOS (and even LPY) that aided their low GI potentials. This is likely because Oko et al. [26] reported different amylose and amylopectin contents in different yam's varieties used for IPYFs production. Additionally, acid in food slows down stomach emptying, which slows down the rate of digestion of carbohydrates. Increasing the acidity of a meal could lower the blood sugar response and GI [31]. It is therefore possible that the acidic content of these IPYFs was increased in the course of production for this purpose.

The minimal postprandial glucose peaks and little IAUCs (glycemic responses) of APYTOS, IPYTOS and EPYTOS imply that; these meals were slowly digested to gradually release glucose into the blood in a way that prevented inordinate rise in blood glucose levels hence, the reason for their little IAUCs and significantly low GIs and GLs in Table 3, because GI and GL are directly proportional to IAUC, which in turn is dependent on postprandial glucose peaks. The higher the IAUC of a meal, the higher its GI & GL, and vice-versa [36]. Consequently and conversely to APYTOS, IPYTOS and EPYTOS meals, the high postprandial glucose peaks and IAUCs of DG, OPYTOS, LPY and LPYTOS suggest that these meals, most especially DG and OPYTOS, would be rapidly metabolized to create spike in blood glucose that could lead to high GI and GL shown in Table 3.

Furthermore, the significant reductions in GI and GL, and lesser postprandial glucose peak and IAUC shown in Table 3 and Figure 1 respectively when LPY was consumed with TOS (LPYTOS) in comparison with when consumed alone are clear indications that truly, the veggie is rich in health-benefiting/promoting nutrients like fiber, crude protein and fat (most likely unsaturated fat) as shown in Table 1, which had consequently and potently impacted GI and GL positively. In a nutshell, GI and GL are directly proportional to blood glycemic responses, postprandial glucose peaks and IAUCs. The lower the GI value of a meal; the lower the blood glucose level, insulin level, glycemic response, postprandial glucose peak and IAUC, and vice versa [36].

According to Brand-Miller et al. [31] and Ludwig [12], low GI foods (like APYTOS, IPYTOS and EPYTOS) would prevent inordinate rise in blood glucose levels, insulin spike, insulin resistance and consequently DM on prolong consumption, and vice-versa. Sequel to this, APYTOS, IPYTOS and EPYTOS consumption could therefore be considered better than LPY consumption due to their low GIs in the prevention of DM however, their high GLs is worrisome and could undermine their regular consumption.

Since GL accounts for the amount of carbohydrate in foods (i.e. takes into consideration the amount of carbohydrate consumed) in addition to glycemic response; less than 50 g of available carbohydrate of these instant pounded yam flours is therefore recommended for consumption, and GL is thus a better indicator of how carbohydrate foods would affect blood glucose (glycemic response), and should be considered alongside GI in order to select appropriate portion (size or quantity) of a meal that is good for one's health.

Limitation of the Study

The small sample size used in this research study is a limitation to the study. It becomes unavoidable due to the unwillingness of the study population (students) to participate in the research study because of the likelihood of missing lectures, tutorials, continuous assessments etc. because the study protocols demand the subjects (participants) be confined to the experimental area for about 4-5 hours in a day for seven consecutive days to enhance proper monitoring and experimentation.

Moreover, the fear of being finger-pricked for five or more times in a day for seven consecutive days, and non-compliance of some participants to study protocols also play some roles in this limitation.

Acknowledgement

I give thanks to God Almighty for His unlimited favor, divine inspiration, guidance and protection throughout the period of this research. I also thank Dr. O.A. Obembe for his contributions toward the success of this study, most especially in identifying the food samples. I appreciate Mrs. I.H. Ajayi and Mrs. O.C. Ejelenu for their assistance. The supports of Prof. (Mrs.) Olusola D. Omueti in all ramifications cannot be forgotten in a hurry. I deeply acknowledge the support and cooperation of my family that spur me into action for speedy completion of this study. God bless you all.

References

1. Olaoye JO, Oyewole SN (2012) Optimization of some poundo yams production parameters. Agric Eng Int: CIGR Journal 14: 58-67.
2. Aworh OC (2008) The role of traditional food processing technologies in national development: The West African experience. In: Robertson GL, Lupien JR (editors) Using food science and technology to improve nutrition and promote national development. International Union of Food Science & Technology pp: 1-18.
3. Federal Institute of Industrial Research, Oshodi (2015) Industrial profile on instant pounded yam flour. Daily times.
4. Fasanmade AA, Anyakudo MMC (2007) Glycemic indices of selected Nigerian flour meal products in male type 2 diabetic subjects. Diabetologia Croatica 36: 33-38.
5. Evans EC, Gajere Y (2017) The glycemic index and load of different Nigerian food forms. Int Res J Biochem Bioinfo 7: 1-11.
6. Jenkins DJ, Wolever TM, Taylor RH (1981) Glycemic index of foods: A physiological basis for carbohydrate exchange. Am J Clin Nutr 34: 362-366.
7. Brouns F, Bjorch I, Frayn KN, Gibbs AL, Lang V, et al. (2005) Glycemic index methodology. Nutr Res Rev 18: 145-171.
8. Linus Pauling Institute. Glycemic index and glycemic load: Micronutrient information center. Oregon State University.
9. Glycemic Research Institute (2013) Glycemic Load Defined.
10. www.en.m.wikipedia.org./wiki/glycemicload
11. Foster-Powell KF, Holt SHA, Brand-Miller JC (2002). International table of glycemic index and been worth glycemic load. Am J Clin Nutr 76: 5-56.
12. Ludwig DS (2002) The glycemic index: Physiological mechanisms relating to obesity, diabetes and cardiovascular diseases. JAMA 287: 2414-2423.
13. Neuhouser ML, Tinker LF, Thompson C (2006) Development of a glycemic index database for food frequency questionnaires used in epidemiologic studies. J Nutr 136: 1604-1609.
14. Willett W, Manson J, Liu S (2002) Glycemic index, glycemic load, and risk of type 2 diabetes. Am J Clin Nutr 76: 274S-280S.
15. Hodge AM, English DR, O'dea K, Giles GG (2004) Glycemic index and dietary fiber and the risk of type 2 diabetes. Diabetes Care 27: 2701-2706.
16. Augustin LS, Gallus S, Bosetti C, Levi F, Negri E, et al. (2003) Glycemic index and glycemic load in endometrial cancer. Int J Cancer 105: 404-407.
17. Association of Official Analytical Chemists (1995) Official methods of analysis (16thedn) Washington DC, USA.
18. Wolever TM, Jenkins DJ, Jenkins AL, Josse RG (1991) The glycemic index: Methodology and clinical implications. Am J Clin Nutr 54: 846-854.
19. Emaleku SA (2013) The glycemic index of soy flour fortified whole wheat meal consumed with crassocephalum biafrae (worowo) soup and the lipid profile of the test human subjects. Thesis: Adekunle Ajasin University, Akungba-Akoko, Ondo State, Nigeria pp: 45-46.
20. Freeman H (2005) Slowly digested and absorbed carbohydrate in traditional bush foods: A protective factor against diabetes. Diabetes care 321:436-443.
21. Brand-Miller JC, Holt SH, Pawlak DB, McMillan J (2002) Glycemic index and obesity. Am J Clin Nutr 76: 281-285.
22. Henry CJ, Lightowler HJ, Kendall FL, Storey M (2006) The impact of the addition of toppings/fillings on the glycaemic response to commonly consumed carbohydrate foods. Eur J Clin Nutr 60: 763-769.
23. Hätönen KA, Virtamo J, Eriksson JG, Sinkko HK, Sundvall JE, et al. (2011) Protein and fat modify the glycaemic and insulinaemic responses to a mashed potato-based meal. Br J Nutr 106: 248-253.
24. Owen B, Wolever TM (2003) Effect of fat on glycemic responses in normal subjects: A dose-response study. Nutr Res 23: 1341-1347.
25. Turner ND, Lupton JR (2011) Dietary fiber. Adv Nutr 2: 151-152.
26. Oko AO, Famurewa AC, Nwaza JO (2015) Proximate composition, mineral elements and starch characteristics: Study of eight (8) unripe plantain cultivars in Nigeria. British J Applied Sci Tech 6: 285-294.
27. Chen YJ, Sun FH, Wong SH, Huang YJ (2010) Glycemic index and glycemic load of selected Chinese traditional foods. World J Gastroenterol 16:1512-1517.
28. Henry CJ, Lightowler HJ, Strik CM, Renton H, Hails S (2005) Glycaemic index and glycaemic load values of commercially available products in the UK. Br J Nutr, 94: 922-930.
29. Al Dhaheri AS, Al Ma'awali AK, Laleye LC, Washi SA, Jarrar AH, et al. (2015) The effect of nutritional composition on the glycemic index and glycemic load values of selected Emirati foods. BMC Nutrition 1: 1-8.
30. Aston LM, Gambell JM, Lee DM, Bryant SP, Jebb SA (2008) Determination of the glycaemic index of various staple carbohydrate-rich foods in the UK diet. Eur J Clin Nutr 62: 279-285.

31. Brand-Miller J, Hayne S, Petocz P, Colagiuri S (2003) Low-glycemic index diets in the management of diabetes- a meta-analysis of randomized controlled trials. Diabetes Care 26: 2261-2267.
32. Lehmann U, Robin F (2007) Slowly digestible starch-its structure and health implications: A review. Trends Food Sci Technol 18: 346-355.
33. Alinnor JI, Akalezi CO (2010) Proximate and mineral composition of Dioscorea rotundata (white yam) and Colocasia esculenta (white cocoyam). Pakistan J Nutr 9: 998-1001.
34. Leng MS, Gouado I, Ndjouenkeu R (2011) Blanching and drying behavior of Dioscorea schimperiana and impact on cellular exchanges and on calcium, ascorbic acid and β-carotene contents. Am J Food Technol 6:362-373.
35. Behall KM, Scholfield DF, Hallfrisch JG, Liljeberg-Elmstahl HG (2006) Consumption of both resistant starch and β-glucan improves postprandial plasma glucose and insulin in women. Diabetes Care 29: 976-981.
36. Emaleku SA, Omueti OD, Emaleku GO (2017) Whole wheat meal fortified with soy flour consumed with Talinum triangulare (gbure) soup glycemic index and the test human subjects' lipid profiles. Diabetes Metab Syndr.