



Comparative Evaluation of Glycemic Indexes and Glycemic Loads of Four Industrial Pounded Yams Consumed with *Talinum triangulare* and *Telfairia occidentalis* Vegetable Soups

S.A. EMALEKU

¹ Department of Biochemistry, Adegunle Ajasin University, Akungba-Akoko, Ondo State, Nigeria

*Corresponding author E-mail address: crowsage@yahoo.com; sunday.emaleku@aaau.edu.ng

Abstract

Keywords:

Indigenous pounded yam;
Industrial pounded yam;
Glycemic index; Glycemic load

Pounded yam is one of the major staple foods in Nigeria; most especially, in the south west part of the country. In recent years, industrial pounded yams were introduced into the markets so as to eradicate the laborious activities associated with the preparation of the indigenous one. However, the glycemic index (GI) and glycemic load (GL) of these various pounded yams are not well established. Therefore, the aim of this study is to comparatively evaluate the GIs and GLs of four Nigerian industrial pounded yams consumed with *Talinum triangulare* and *Telfairia occidentalis* vegetable soups respectively. Prepared industrial pounded yams such as Ayoola pondo yam (APY), Endy's pondo yam (EPY), Iyan pondo yam (IYPY) and Ola-Ola pondo yam (OOPY) were consumed with *Talinum triangulare* soup (TTS) and *Telfairia occidentalis* soup (TOS) respectively by human subjects. These subjects also consumed the control meal; indigenous pounded yam (IPY), and standard reference meal (D-glucose). Their blood glucose levels were determined, and used to calculate the foods' GIs and GLs. Results showed that; the GIs ($42.33 \pm 0.33\%$, $42.33 \pm 1.85\%$ and $44.00 \pm 1.53\%$) and GLs (22.00 ± 0.00 , 22.00 ± 1.00 and 22.67 ± 0.67) of EPYTTS, APYTTS and IYPYTTS respectively differed significantly from the GIs and GLs of other meals, except APYTOS' GI ($46.00 \pm 2.08\%$) and GL (23.33 ± 1.20). Therefore, EPYTTS, APYTTS and IYPYTTS are low GI foods although, with high GL values, and TTS seems to work synergistically with these industrial pounded yams better than TOS to enhance low GI values.

Accepted: 7 June 2019

© Science Research Annals. All rights reserved.

INTRODUCTION

Pounded yam is a carbohydrate food that serves as one of the major staple foods in Nigeria; most especially in the south west region of the country (Sahel Capital Partners & Advisory Limited, 2014; Emaleku, 2017), but its preparation is often laborious and often burdensome (Olaoye and Oyewole, 2012; Emaleku, 2017). However, the emergence of

different industrial pounded yam flours (IPYFs) in recent years has helped to reduce or overcome the drudgery, stress and strenuous activities associated with the preparations of indigenous pounded yam (IPY) (Aworh, 2008; FIRO, 2015; Emaleku, 2017). It has also in one way or the other helped increase the number of people consuming pounded yam, and even how often they consume it, because of its convenient preparation method that by-passes the hurdles of pounding in mortar with pestle common with IPY.

Howbeit, only little or dearth information exists on the glycemic index (GI) and glycemic load (GL) of these pounded yams (both indigenous and industrial) often consumed with delicacy of different vegetable soups (Fasanmade and Anyakudo, 2007; Emaleku, 2017; Evans and Gajere, 2017). It is pertinent to say at this juncture that; the knowledge of GI and GL is very key in the rationale advice on calories recommendation for consumption by humans because, high GI and GL foods could predispose man to diabetes mellitus (DM) and its complications, while low GI and GL foods could reduce the risk of having DM, CVDs and other related diseases (Oko *et al.*, 2015; Emaleku *et al.*, 2018). According to Feskens and Du (2006), GI concept was developed to help control blood glucose levels in diabetic patients when it was evident that high GI foods consumption was associated with an increased risk of type 2 diabetes mellitus based on Willett *et al.* findings in 2002.

GI refers to the 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). It is a measure of the blood glucose-raising ability of the available carbohydrate in foods (Wolever *et al.*, 2008). While GL, is the numerical measurement of carbohydrate constituted in a food by measuring the carbohydrate consumed in a particular diet in addition to its ability to raise blood glucose levels (Fooster-Powell *et al.*, 2002). In other word, GL takes into account the amount of carbohydrate in a portion of meal in addition to how quickly the meal raises the blood glucose levels of the subjects (Diabetes.co.uk, 2017). According to Willett *et al.* (2002), the consumption of high GI and GL diets for several years might result in higher postprandial blood glucose concentrations and excessive insulin secretion that might eventually contribute to the loss of insulin-secreting function of the beta cells (one of the characteristic effects of DM), and thereby leads to irreversible type 2 DM. Conversely, epidemiological and dietary intervention studies revealed that low GI foods are beneficial to man for blood glucose control, and could prevent insulin resistance that is often common with high GI foods (Neuhouser *et al.*, 2006). Thus, this study was embarked upon to comparatively evaluate the glycemic index and glycemic load of four industrial pounded yams consumed with *Talinum triangulare* and *Telfairia occidentalis* vegetable soups respectively in order to give valid information to the public about their GI and GL values that will in turn inform the consumption choice and rate of these foods, since GI and GL are implicative in or could worsen the

condition of some chronic diseases rampaging the world today.

Subjects, 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 $23.13 \pm 2.53 \text{ kg/m}^2$ were randomly selected and used for this study after approval for the study had been obtained from the Health Research Ethical Committee of the Federal Medical Centre, Owo, Ondo State. Subjects signed a written agreement in addition to verbal expression of their willingness and interest to participate in the research after consultation. The subjects were clinically normal, non-smokers, non-alcoholics, non-hyperlipidemia and non-diabetic students and they followed the study protocols (rules) without any prejudice to their social and religious status, and remained within the confinement of the experimental area during the experimental period.

Food stuff

Food stuffs such as *Talinum triangulare* leafy vegetable, *Telfairia occidentalis* leafy vegetable, white yam (*Dioscorea rotundata*), Ayoola, Iyan, Olaola and Endy's pouno yam flours, and some condiments were purchased at Ibaka-Akungba local market, Ondo State, Nigeria. The veggies and yam were identified and authenticated by a competent curator in the Department of Plant Science and Biotechnology, Faculty of Science, Adekunle Ajasin University, Akungba-Akoko, Ondo State.

Food stuff preparation

The meals were prepared according to the method reported by Emaleku (2017). The two vegetable soups were prepared by washing the fresh leafy vegetables, shredding into slices of almost equal sizes and addition of condiments such as 20 g onions, 40 g pepper (atarodo), 60 g locust bean, 1 g of salt and 120 ml palm oil, and steaming for about 10 min. Furthermore, IPY was prepared by peeling and slicing the yam, cooked until softened, and pounded in a mortar using a pestle to smoothen the dough (solid paste), while the industrial pouno yam flours (Ayoola, Iyan, Olaola and Endy's pouno yam flours) were respectively prepared in hot water by continuous stirring until they became smooth solid pastes. Finally, the standard reference meal (D-glucose) was prepared by dissolving 50 g of D-glucose (DG) in 100 ml of water.

Proximate composition of foods

The proximate composition of the food samples i.e. solid pastes of IPY, Ayoola pondo yam (APY), Iyan pondo yam (IYPY), Ola-ola pondo yam (OOPY), Endy's pondo yam (EPY), and the vegetable soups; *Talinum triangulare* soup (TTS) and *Telfairia occidentalis* soup (TOS) were determined using conventional standard methods of analysis described by the Association of Official Analytical Chemists, AOAC (1995).

Feeding of human subjects

Thirty human subjects consumed D-glucose (DG) as the standard reference meal, indigenous pounded yam (IPY) as the control meal, and indigenous pounded yam with *Talinum triangulare* soup (IPYTTS), indigenous pounded yam with *Telfairia occidentalis* soup (IPYTOS), Ayoola pondo yam with *Talinum triangulare* soup (APYTTS), Endy's pondo yam with *Talinum triangulare* soup (EPYTTS), Iyan pondo yam with *Talinum triangulare* soup (IYPYTTS), Ola-Ola pondo yam with *Talinum triangulare* soup (OOPYTTS), Ayoola pondo yam with *Telfairia occidentalis* soup (APYTOS), Endy's pondo yam with *Telfairia occidentalis* soup (EPYTOS), Iyan pondo yam with *Telfairia occidentalis* soup (IYPYTOS) and Ola-Ola pondo yam with *Telfairia occidentalis* soup (OOPYTOS) as the test meals on the 1st, 2nd, 3rd, 4th, 5th, 6th, 7th and 8th, 9th, 10th, 11th, and 12th day of the experiment respectively (i.e. from 10th to 21st of October, 2016) after 12 h of overnight fasting. The quantity of solid pastes consumed was 50 g of available carbohydrate.

Blood glucose determination

The blood glucose levels of human subjects were determined following the procedures reported by Emaleku (2017) and Emaleku *et al.* (2018). Blood glucose levels of human subjects were determined using portable glucometer by finger pricking; once before meals (pre-prandial) and four times after meals (postprandial) for two hours at 30 min interval.

Glycemic index determination

Emaleku (2013); (2017) and Emaleku *et al.* (2018) method was used to determine the GIs of meals. Blood glucose response curve graphs of human subjects were plotted for the various meals and the incremental areas under curves (IUACs) calculated by summing up the surface triangles and rectangles under the blood glucose response curve graphs. The GI of each test meal and/or control meal was then gotten by dividing the IAUC of the test meals/or control meal by IUAC of the standard reference meal (DG) multiply by 100.

Glycemic load determination

GL was calculated from GI following conventional method reported by Emaleku (2017) and Emaleku *et al.* (2018). GL was gotten by dividing GI of meal by 100 and multiplied by the number of available carbohydrate in the meal consumed (50 g in this case).

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. 0.05 level of significance was used, and data presented as mean \pm standard error mean (SEM).

RESULTS

Table I: Proximate composition of pounded yams

Sample ID	Moisture (%)	Ash (%)	Fat (%)	Fiber (%)	Protein (%)	Carbohydrate (%)
APY	50.36 \pm 0.25 ^e	0.49 \pm 0.04 ^{cc}	2.92 \pm 0.19 ^{cc}	0.74 \pm 0.10 ^{aa}	5.60 \pm 0.25 ^{bb}	39.89 \pm 0.32 ^{aa}
EPY	58.31 \pm 0.28 ^a	0.45 \pm 0.05 ^{cc}	3.22 \pm 0.14 ^{cc}	0.57 \pm 0.07 ^{ab}	4.18 \pm 0.26 ^{cc}	33.27 \pm 0.13 ^{cc}
IYPY	55.35 \pm 0.41 ^c	1.11 \pm 0.03 ^{ab}	4.43 \pm 0.25 ^{aa}	0.24 \pm 0.03 ^{cc}	4.25 \pm 0.25 ^{cc}	34.62 \pm 0.18 ^{bb}
OOPY	56.80 \pm 0.27 ^b	1.01 \pm 0.08 ^{bb}	3.41 \pm 0.04 ^{bc}	0.41 \pm 0.05 ^{bc}	5.16 \pm 0.27 ^{bb}	33.20 \pm 0.10 ^{cc}
IPY	53.71 \pm 0.26 ^d	1.24 \pm 0.11 ^{aa}	4.15 \pm 0.42 ^{ab}	0.51 \pm 0.09 ^{ab}	6.63 \pm 0.07 ^{aa}	33.76 \pm 0.70 ^{bc}

Key: APY-Ayoola pondo yam; EPY-Endy's pondo yam; IYPY-Iyan pondo yam; OOPY-Ola-ola pondo yam and IPY-Indigenous pounded yam.

Note: Comparison is strictly within parameter (down the column) and results presented in mean \pm SEM. Values with different superscript letter(s) are significantly different at 0.05 level of significance.

Table I results revealed that fiber content (0.74±0.10%; 0.57±0.07% and 0.51±0.09%) of APY, EPY and IPY respectively differed significantly at 0.05 significance level from that (0.41±0.05% and 0.24±0.03%) of OOPY and IYPY respectively. It also showed that IPY's protein content (6.63±0.07%) differed significantly from that of other meals; APY (5.60±0.25%), OOPY (5.16±0.27%), IYPY (4.25±0.25%) and EPY (4.18±0.26%). Moreover, fat content (4.43±0.25% and 4.15±0.42%) and ash content (1.11±0.03% and 1.24±0.11%) of IYPY and IPY respectively were significantly different from fat content (3.22±0.14% and 2.92±0.19%) and ash :

content (0.45±0.05% and 0.49±0.04%) of EPY and APY respectively, but not significantly different from OOPY's fat (3.41±0.04%) and ash (1.01±0.08%) contents although, IYPY's fat content was significantly different from OOPY's fat content. Furthermore, the moisture content of APY (50.36±0.25%) was significantly different from the moisture content of other pounded yam solid pastes. In addition, APY's carbohydrate content (39.89±0.32%) was significantly different from that of other solid paste meals.

Table 2: Proximate composition of vegetable soups

Sample ID	Moisture (%)	Ash (%)	Fat (%)	Fiber (%)	Protein (%)	Carbohydrate (%)
TTS	63.26±0.20 ^a	1.64±0.16 ^{ab}	12.77±0.18 ^a	4.60±0.14 ^a	16.12±0.25 ^a	1.00±0.12 ^a
TOS	63.04±0.25 ^a	1.87±0.17 ^a	12.48±0.04 ^{ab}	4.99±0.21 ^a	16.61±0.27 ^a	1.61±0.35 ^a

Key: TTS-*Talinum triangulare* soup; TOS-*Telfairia occidentalis* soup

Note: Comparison is strictly within parameter (down the column) and results presented in mean ± SEM. Values with different superscript letter(s) are significantly different at 0.05 level of significance.

Table 2 showed that at 0.05 significance level, there was no significant difference between TTS and TOS in all proximate composition parameters.

Table 3: Glycemic index and glycemic load of pounded yams consumed with *Talinum triangulare* and *Telfairia occidentalis* soups

Meals	Glycemic index (%)	Glycemic load
D-Glucose	100.00±0.00 ^{aa}	50.00±0.00 ^{aa}
APYTOS	46.00±2.08 ^{ef}	23.33±1.20 ^{de}
APYTTS	42.33±1.85 ^{fg}	22.00±1.00 ^{ee}
EPYTOS	50.33±1.45 ^{ee}	26.00±0.58 ^{dd}
EPYTTS	42.33±0.33 ^{fg}	22.00±0.00 ^{ee}
IPY	68.33±0.33 ^{bb}	34.67±0.33 ^{bb}
IPYTOS	60.33±1.86 ^{cc}	31.67±1.20 ^{cc}
IPYTTS	56.33±1.20 ^{cd}	29.00±0.58 ^{cc}
IYPYTOS	48.67±0.88 ^{ee}	25.00±0.58 ^{dd}
IYPYTTS	44.00±1.53 ^{fg}	22.67±0.67 ^{ee}
OOPYTOS	69.67±1.45 ^{bb}	35.67±0.88 ^{bb}
OOPYTTS	57.00±2.52 ^{cd}	29.33±1.20 ^{cc}

Key: APY-Ayoola pounded yam; EPY-Endy's pounded yam; IYPY-Iyan pounded yam; OOPY-Ola-ola pounded yam; IPY-Indigenous pounded yam; TTS-*Talinum triangulare* soup; TOS-*Telfairia occidentalis* soup.

Note: Comparison is strictly within parameter (down the column) and results presented in mean ± SEM. Values with different superscript letter(s) are significantly different at 0.05 level of significance.

Table 3 result showed that; the GIs ($42.33 \pm 0.33\%$, $42.33 \pm 1.85\%$ and $44.00 \pm 1.53\%$) and GLs (22.00 ± 0.00 , 22.00 ± 1.00 and 22.67 ± 0.67) of EPYTTS, APYTTS and IYPYTTS respectively were significantly different from the GIs and GLs of other meals, except APYTOS' GI ($46.00 \pm 2.08\%$) and GL (23.33 ± 1.20) at ($P < 0.05$). Furthermore, result revealed that consumption of pounded yam solid pastes with *Talinum triangulare* soup (TTS) resulted in lesser GIs and GLs than when they were consumed with *Telfairia occidentalis* soup (TOS) as observed in EPYTTS' GI ($42.33 \pm 0.33\%$), GL (22.00 ± 0.00) and EPYTOS' GI (50.33 ± 1.45), GL (26.00 ± 0.58). Moreover, there were significant differences (reductions) between IPY's GI ($68.33 \pm 0.33\%$) and GL (34.67 ± 0.33) when consumed alone and when consumed with TTS and TOS GIs ($56.33 \pm 1.20\%$ and $60.33 \pm 1.86\%$) and GLs (29.00 ± 0.58 and 31.67 ± 1.20) respectively at 0.05 level of significance.

DISCUSSION

Carbohydrate meals like yams, pounded yams are often avoided, especially by adults from the age of 40 and above because of the fear of diabetes, a glucose metabolic disorder/disease International Diabetes Federation (IDF) reported to cause 4 million deaths of adults globally in 2017. This caution is good but, it should be pointed out that indigenous pounded yam (IPY) and most of these industrial pounded yam flours possess some amazing nutritional properties of health importance as revealed by the proximate composition results of this study. The significantly high fiber contents of APY, EPY and IPY according to Turner and Lupton (2011), Oko *et al.* (2015) and Rudrappa (2017) implies that, they could possess the potential to reduce blood cholesterol and bad low density lipoprotein cholesterol (LDL-C) levels, slow down glucose absorption, improve insulin sensitivity that will as well reduce the incidence of obesity, coronary heart diseases (CHDs), type 2 DM, digestive disorders (constipation) and some cancers.

In support of this above statement, Kranz *et al.* (2012) reported that low level consumption of fiber over time could lead to several adverse physiological responses most especially, increased risk of type 2 DM and CHD. Furthermore, the significant high fat and ash contents of IYPY and IPY, and high protein content of IPY, APY and OOPY are also of health benefits to mankind. According to Henry *et al.* (2006), high fat and protein contents have the potential to reduce glycemic response, thereby lowering the overall GI of foods, while low intake of protein may lead to several impaired biological processes in the body (Oko and Famurewa, 2015). More also, Owen and Wolever in 2003 found that

eating white bread (a high glycemic index meal) containing 50 g of available carbohydrate with a high quantity (40 g) of non-hydrogenated margarine fat significantly reduced incremental area under the curve (IAUC) and blood glucose response by 30%, and that fat would influence the interaction of plasma glucose, insulin and gastric inhibitory peptide (GIP) (Owen and Wolever, 2003) to bring about reduction in blood glucose levels. It is worthy of note to say that these findings are in agreement with that of Olaoye and Oyewole (2012) although, they reported higher crude fat (4.79%) and protein (6.63%) contents for an unnamed IPYF.

Moreover, the significantly low GI and GL values of EPYTTS, APYTTS and IYPYTTS further show the superior health benefiting effects of these foods/meals over the other foods'/meals' GIs and GLs, except APYTOS. According to Wolever *et al.* (2008), low GI diets are associated with increased insulin sensitivity, reduced food intake, reduced body weight gain, and may reduce serum cholesterol. Therefore, the low GIs of EPYTTS, APYTTS and IYPYTTS imply that they would only slightly raise blood glucose levels of subjects to cause little spike in insulin level with low glycemic response (Emaleku *et al.*, 2018), and not inordinately raise blood glucose and insulin levels of subjects to the extent that will impair pancreatic beta cell function and endothelial function that may in turn increase the risk of diabetes, obesity and CHDs (Ludwig, 2002) via some biochemical reactions that promote excessive food intake (Emaleku, 2017; Emaleku *et al.*, 2018). Low GI foods can improve metabolic mechanism in adult patients with type 2 diabetes mellitus and according to Brand-Miller *et al.* (1992), consumption of low GI foods in medium term can control blood glucose level.

Although, there was no significant difference in all proximate composition parameters between TTS and TOS however, TTS consumption with the industrial pounded yam solid pastes as well as with when consumed with IPY solid paste, resulted in better glycemic response than when TOS was consumed with these solid pastes, and this improved glycemic response in turn led to the observed better and lower GIs and GLs shown in Table II, Figures I and II. It is imperative to note that even with the observed low GI values of EPYTTS, APYTTS and IYPYTTS, their GL are still high based on international standard classification that classified GL of foods ≥ 20 as high GL foods (Liu, 2016). This is particularly worrisome and calls for caution in the regular consumption of these industrial pounded yams because, high GL meals connote; their consumption for a long time

could cause repeated blood glucose/insulin spike that might in turn lead to insulin resistance, which would then increase the chance of the individual having DM and CVDs (Liu *et al.*, 2000; Willet *et al.*, 2002). This brings to mind the statement of Foster-Powell *et al.* (2002) that “GL is a better indicator of how carbohydrate food would affect blood glucose”. It helps to select the appropriate portion (size or quantity) of a meal that is good for one’s health. Since it is apparently evident that GI and GL are aspects of diet of great importance in the treatment and prevention of DM and some chronic diseases, it is therefore obvious that consumption of EPYTTS, APYTTS and IYPYTTS containing 50 g of available carbohydrate might still predispose man to DM and CVDs if consumed on a daily basis because their high GL values.

Sequel to all these findings, it can be concluded that EPYTTS, APYTTS and IYPYTTS meals are low GI foods with lower GL values than OOPYTTS, OOPYTOS, EPYTOS, APYTOS, IYPYTOS, IPY, IPYTTS and IPYTOS, and TTS seems to work synergistically with these industrial pounded yam solid pastes to enhance low GI and GL values better than TOS since all the pounded yams consumed with TTS have lesser GI and GL values than when they were consumed with TOS. Nevertheless, the consumption of EPYTTS, APYTTS and IYPYTTS containing less than 50 g of available carbohydrate in the medium term is thus recommended because of their > 20 GL values, which could be detrimental on the long run.

ACKNOWLEDGEMENT

I am in deed grateful to God Almighty for His awesome protection, guidance and unquantifiable love and favor. I also appreciate the assistance and support of Prof. (Mrs.) O.D. Omueti toward the success of this study. My profound gratitude equally goes to all my colleagues in the Department of Biochemistry, Adekunle Ajasin University, Akungba-Akoko (AAUA), Ondo State. Special thanks to Dr. O.A. Obembe, the incumbent HOD of the Department of Plant Science and Biotechnology, AAUA for his assistance. I unequivocally and sincerely appreciate the encouragement, support and cooperation of my wife and children that brought this study to a quick completion.

REFERENCES

Association of Official Analytical Chemists (1995). Official methods of analysis (16th ed.). Washington DC, USA; AOAC.

- Aworh, O.C. (2008). The role of traditional food processing technologies in national development: The West African experience. Using food science and technology to improve nutrition and promote national development. Robertson, G.L. & Lupien, J.R. (Eds). *International Union of Food Science & Technology*. Pp. 1–18.
- Brand-Miller, J., Pang, E. and Bramall, L. (1992). Rice: a high or low glycemic index food. *Am. J. Clin. Nutr.* 58, 1034-1036.
- Diabetes.co.uk (2017). Diabetes Digital Media Limited. The Global Diabetes Community. (Online). Available at: www.diabetes.co.uk/diet/glycemic-load (Accessed 28 August, 2017).
- Emaleku, S.A. (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.* 8:12. DOI: 10.4172/2155-6156.1000777.
- Emaleku, S.A. (2013). The glycemic index of soy flour fortified whole wheat meal consumed with *Crassocephalum bialfrae* (worowo) soup and the lipid profile of the test human subjects. B.Sc. Thesis. Adekunle Ajasin University, Akungba-Akoko, Ondo State, Nigeria.
- Emaleku, S.A., Emaleku, G.O. and Omueti, O.D. (2018). Soy flour fortification of whole wheat meal possessed low glycemic index and glycemic load and reduced cardiovascular disease risk factors. *J. Cardiovasc. Dis. Diagn.* 6:2. DOI: 10.4172/2329-9517.1000313.
- Emaleku, S.A., Omueti, O.D. and Emaleku, G.O. (2018). *Talinum triangulare*: Whole wheat meal fortified with soy flour consumed with *Talinum triangulare* (gbure) soup glycemic index and the test human subjects’ lipid profiles. *Diab. & Metab. Syndr: Clin. Res. & Rev.* 12:831-837.
- Evans, E.C. and Gajere, Y. (2017). The glycemic index and load of different Nigerian food forms. *Int. Res. J. Biochem. & Bioinformat.* 7(1):1-11.
- Fasanmade, A.A. and Anyakudo, M.M.C. (2007). Glycemic indices of selected Nigerian flour meal products in male type 2 diabetic subjects. *Diabetologia Croatica.* 36(2):33-38.
- Federal Institute of Industrial Research, Oshodi (2015). Industrial profile on instant pounded yam flour. Daily times; (online). Available at: <http://www.dailytimes.ng/business/industrial-profile-on-instant-pounded-yam-flour/amp/> (Accessed 15 August, 2017).
- Feskens, E.J. and Du, H. (2006). Dietary glycaemic index from an epidemiological point of view. *Int. J. Obes. (Lond)*; 30 Suppl 3:S66-S71.

- Foster-Powell, K.F., Holt, S.H.A. and Brand-Miller, J.C. (2002). International table of glycemic index and been worth glycemic load. *Am. J. Clin. Nutr.* 76:5-56.
- Henry, C.J., Lightowler, H.J., Kendall, F.L. and Storey, M. (2006). The impact of the addition of toppings/fillings on the glycemic response to commonly consumed carbohydrate foods. *Eur. J. Clin. Nutr.* 60(6):763–769.
- International Diabetes Federation (2017). IDF Atlas, 8th Edition Global Fact Sheet. www.idf.org/52-about-diabetes.html.
- Jenkins, D.J., Wolever, T.M. and Taylor, R.H. (1981). Glycemic index of foods: A physiological basis for carbohydrate exchange. *Am. J. Clin. Nutr.* 34:362–366.
- Kranz, S., Brauchla, M., Slavin, J.L. and Miller, K.B. (2012). What do we know about dietary fiber intake in children and health? The effects of fiber intake on constipation, obesity and diabetes in children. *Adv. Nutr.* 3:47-53.
- Liu, S. (2016). Glycemic index and glycemic load. Linus Pauling Institute. <https://lpi.oregonstate.edu/mic/food-beverages/glycemic-index-glycemic-load>.
- Liu, S., Willett, W., Stampfer, M.J., Hu, F.B., Franz, M. and Sampson, L. (2000). A prospective study of dietary glycemic load, carbohydrate intake, and risk of coronary heart disease in US women. *Am. J. Clin. Nutr.* 71(6):1455-1461.
- Ludwig, D.S. (2002). The glycemic index: Physiological mechanisms relating to obesity, diabetes and cardiovascular diseases. *J. Am. Med. Assoc.* [online], 287(18):2414-2423. Available at: www.google.com (Accessed 20 August, 2017).
- Neuhouser, M.L., Tinker, L.F. and Thompson C. (2006). Development of a glycemic index database for foodfrequency questionnaires used in epidemiologic studies. *J. Nutr.* 136:1604-1609.
- Oko, A.O. and Famurewa, A.C. (2015). Estimation of nutritional and starch characteristics of *Dioscorea alata* (water yam) varieties commonly cultivated in the south-eastern Nigeria. *Br. J. Appl. Sci. & Tech.* (online) 6(2):145-152. Available at: www.sciencedomain.org (Accessed 2 August, 2017).
- Oko, A.O., Famurewa, A.C. and Nwaza, J.O. (2015). Proximate composition, mineral elements and starch characteristics: Study of eight (8) unripe plantain cultivars in Nigeria. *Br. J. Appl. Sci. & Tech.* (online) 6(3):285-294. Available at: www.sciencedomain.org (Accessed 2 August, 2017).
- Olaoye, J.O. and Oyewole, S.N. (2012). Optimization of some “poundo” yams production parameters. *Agric Eng Int: CIGR Journal*; (online) 14(2):58-67. Available at: <http://www.cigrjournal.org> (Accessed 12 August, 2017).
- Owen, B. and Wolever, T.M. (2003). Effect of fat on glycemic responses in normal subjects: A dose-response study. *Nutr. Res.* 23(10):1341–1347.
- Rudrappa, U. (2017). Yam: The tuber for weight loss and fight against diabetes. [Online]. Available at: www.nutrition-and-you.com. (Accessed 5 August, 2017).
- Sahel Capital Partners & Advisory Limited (2014). Yam improvement for processing (YIP) in Nigeria. Pp. 1-44.
- Turner, N.D. and Lupton, J.R. (2011). Dietary fiber. *Adv. in Nutr.* 2:151-152.
- Willett, W., Manson, J. and Liu, S. (2002). Glycemic index, glycemic load, and risk of type 2 diabetes. *Am. J. Clin. Nutr.* 76(1):274S-280S.
- Wolever, T.M., Mehling, C., Chiasson, J.L., Josse, R.G., Leiter, L.A., Maheux, P., Rabasa-Lhoret, R., Rodger, N.W. and Ryan, E.A. (2008). Low glycemic index diet and disposition index in type 2 diabetes (the Canadian trial of carbohydrates in diabetes): a randomized controlled trial. *Diabetologia.* 51(9):1607-15. doi: 10.1007/s00125-008-1093-x. Epub.