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Glycemic index and glycemic load of yam (*Dioscorea cayenensis-rotundata*) porridge with *Talinum triangulare* sauce tested in human subjects

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Abstract

Yam (*Dioscorea cayenensis-rotundata*) is a major staple foods consumed in Côte d'Ivoire. Their porridge is eaten with different sauces such as *Talinum triangulare* sauce. This study was undertaken to determine the influence of this sauce on the post-prandial response of yam (Kponan variety) porridge.

Methods: Twelve human subjects consumed Kponan boiled, Kponan boiled with *T. triangulare* sauce without fish and Kponan boiled with *T. triangulare* sauce with fish after 10-12 h overnight fasting. Tests food portions containing 50 g of available carbohydrate were evaluated for fasting blood glucose using Accu-chek active glucometer. Glycemic index (GI) and Glycemic Load (GL) were calculated using a standard method with anhydrous glucose as reference food.

Results: The glycosylated hemoglobin of the volunteers was 4.57 % ± 0.01 with fasting blood sugar of 4.71 ± 0.02 mmol / L. The glycemic index (GI) were 61.64 ±11.20, 42.20 ± 3.24 and 41.63 ± 24.56 for Kponan without sauce, Kponan with *T. triangulare* sauce, Kponan with *T. triangulare* + fish sauce respectively. The glycemic load (GL) of Kponan with *T. triangulare* sauce (23.39 ± 1.14), Kponan with *T. triangulare* + fish sauce (19.47 ± 0.13) were lower than that of control meal (Kponan without sauce).

Conclusion: The present survey revealed a significant effect of Ivorian traditional sauces based on *T. triangulare* on GI and GL of Kponan yam. *T. triangulare* sauce improves the nutritional quality of starchy foods and could be consumed by healthy persons or those suffering from diabetes.

Keywords: Glycemic Index; Glycemic Load; Yam; Kponan porridges; Leafy vegetable; *T. triangulare* sauce; Côte d'Ivoire

1. Introduction

The development of diabetes mellitus has been reported to be linked to the intake of high starchy foods [1]. It has affected more than 285 million people around the world and is expected to reach 438 million in the next 17 years [2]. Côte d'Ivoire is placed as the first biggest diabetics' country in the sub-Saharan Africa such as Nigeria and Senegal, with prevalence amounting to 4.93% of the population [3]. The dietary management is important in achieving better glycemic control to reduce the risk of diabetic and to prolong the life expectancy [4]. A major focus of nutritional management of diabetes is the improvement of glycemic control by balancing food intake with endogenous and

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exogenous insulin levels. [5]. The Glycemic Index (GI) values of foods can help dieticians to plan and direct patients / consumers to choose sensible, low GI foods that are believed to reduce the risk of developing type-2 diabetes [4]. But the relationship between diet and diabetes in Cote d'Ivoire is not easy to establish because most existing data are based on Europeans foods, which do not represent meals commonly consumed in this country [6]. Roots and tubers are the third largest carbohydrate food source in the world [7]. Among them, yam (*Dioscorea* sp) is the leading form of staple food for millions of people in the tropical and subtropical countries. Yam representing the first carbohydrate foods in Cote d'Ivoire in volume of production and consumption in spite of the competition of other starchy products such as rice, cassava, corn and plantain [8]. It is eaten with different sauces where *T. triangulare* sauce is one of the most used [9]. However, the sauces added to meal could have an effect on the Glycemic Index (GI) of foods [10]. The objective of the present study was to determine the effect of *T. triangulare* sauce on Glycemic Index and Glycemic Load of yam.

2. Material and methods

2.1. Methods of preparation

The fresh *T. triangulare* leaves were washed in clean water, sliced into small sizes and were precooked in a pot containing one (1) L of boiling water for 5 min. They were drained and then crushed. Other vegetables such as onions and tomatoes were sliced. The pot was washed and placed on a fire and allowed to dry. The palm oil was added and allowed to heat for one (1) min; the onions were then added. The palm oil was not allowed to heat up before adding the onion to avoid hydrogenation. The tomatoes were added and allowed to steam for 2) min. The dry fish (*T. triangulare sauce wit*h fish) and salt were added and allowed to steam for two (2) min. The dough of *T. triangulare* was added and allowed to simmer for 5 min. It was brought down and served [11]. The local yam (Kponan) was prepared by peeling, slicing and was cooked until softened [6].

2.2. Chemical Analysis

The proximate composition (available carbohydrates, proteins, lipids, fibers and ash) of *T. triangulare* sauce, boiled yam, and boiled yam with *T. triangulare* sauce were determined according to the Association of Official Analytical Chemist's method [12]. Available carbohydrate was calculated by difference according to FAO / WHO [13]. Samples were analyzed based on fresh matter and all analyses were in triplicate.

2.3. Subjects

Twelve healthy adults (08 men and 04 women) non-obese with no history of diabetes, hypertension or gastrointestinal tract surgery, were included in the study after they had given a written information consent. The protocol of the study was approved by the scientific committees of NANGUI ABROGOUA University [3].

2.4. Feeding of human subjects

The procedure was explained to volunteers and each signed a consent form. They were instructed to consume no other meal after dinner (not later than 8.00 pm) until breakfast except water; not to take alcohol or smoke, and to maintain the same level of physical exercise. After 10 – 12 h of overnight fasting, the twelve human subjects consumed glucose powder dissolved in 250 ml of water on the first day. The test meals including boiled yam, boiled yam with *T. triangulare* sauce without fish and boiled yam with *T. triangulare* fish sauce were eaten on the 2nd, 3rd and 4th day respectively. The mixed meal contained 5 g of available carbohydrate from *T. triangulare* sauces and 45 g of available carbohydrate from *Dioscorea cayenensis-rotundata* porridge. All meals were served with 250 ml of water [3].

2.5. Calculation of Glycemic Index and Glycemic Load

The blood glucose levels of subjects were determined by Emaleku method [9]. The glycemic index (GI) of meals was calculated using the method described by FAO/WHO [15] as the area under the blood glucose response curve of a 50 g carbohydrate portion of the test food. Values were expressed as a percent of the response to the same amount of carbohydrate from a standard food taken by the same subject. The glycemic index of each sauces were obtained by Sochfer et al. method's [16] and glycemic load for each food was determined by the method of Salmeron et al. [17].

2.6. Data analysis

Analyses were mentioned values as average ± standard deviation (SD). The experimental data were subjected to Analysis Variance (ANOVA) and Duncan's multiple range test for mean separation at P = 0.05 in SATISTICA software version 7.1.

3. Results

3.1. Biochemical composition of sauces

The biochemical composition of *T. triangulare* sauces is shown in Table 1. Except, lipids and available carbohydrate, all biochemical compounds were significantly differents ($p \leq 0.05$). The proteins content ranged from 2.43 ± 0.13 in *T. triangulare* sauce without fish to 6.27 ± 0.52% in *T. triangulare* fish sauce. The polyphenols and fibers contents of *T. triangulare* sauce without fish were higher than that of *T. triangulare* fish sauce. There was no difference between lipids and available carbohydrate contents in *T. triangulare* sauce without fish and *T.* The lipid content in *T. triangulare* fish sauce was lower than *T. triangulare* sauce without fish. The ash in *T. triangulare* fish sauce (2.47± 0.05 %) was significantly higher ($p \leq 0.05$) than that of *T. triangulare* sauce without fish.

Table 1 Biochemical composition of sauces

Sauces	Proteins (%)	Lipids (%)	Fibers (%)	Ash (%)	Available Carbohydrate (%)	Polyphenols (mg / 100g)
STT	2.43 ± 0.13[b]	7.03 ± 0.24[a]	11.77 ± 0.4[a]	1.80 ± 0.01[b]	01.55 ± 0.10[a]	362.90 ± 2.69[a]
STTP	6.27 ± 0.52[a]	6.93 ± 0.36[a]	8.84 ± 0.14[b]	2.47 ± 0.05[a]	01.75 ± 0.18[a]	269.73 ± 2.87[b]

The values are presented as a mean ± standard deviation. Values with no common letter in the same column are significantly different ($p \leq 0.05$). *T. triangulare* sauce without fish (STT), *T. triangulare* sauce with fish (STTP)

3.2. Biochemical composition of tests foods

The biochemical composition of yam porridges and yam porridges with *T. triangulare* sauces are shown in Table 2. No significant difference ($p \leq 0.05$) between all the samples. Regarding ash content, the lowest content was observed in yam porridges. The protein content ranges from 1.22 ± 0.03 % to 4.30 ± 0.31 %. Kponan porridges with *T. triangulare* sauce without fish and Kponan porridges have lower proteins contents. The fat and dietary fibers levels were higher in Kponan porridges with *T. triangulare* sauce without fish. The available carbohydrates differed significantly at the 5% between Kponan porridges and porridges accompanied by sauces. The highest levels carbohydrates were observed in Kponan porridges (38.48 ± 0.53 %). The total polyphenol levels were statistically different at the 5 %. These contents were lower in Kponan porridges (58.88 ± 0.47 mg / 100 g). As for Kponan porridges accompanied sauces with leaves based on *T. triangulare* leaves, the polyphenol content were higher.

Table 2 Biochemical composition of tests foods

Foods Tests	Proteins (%)	Lipids (%)	Fibers (%)	Ash(%)	Available Carbohydrate (%)	Polyphenols (mg / 100g)
BKP	1.22 ±0.03[c]	0.06 ± 0.01[b]	3.12 ± 0.08[c]	0.06 ± 0.01[b]	38.48 ± 0.53[a]	058.88 ± 0.47[c]
BKPTT	1.93 ± 0.28[b]	4.18 ± 0.15[a]	8.23 ± 0.26[a]	1.30 ± 0.01[b]	16.66 ± 0.27[b]	239.16 ± 0.5[a]
BKPTTP	4.30 ± 0.31[a]	4.01 ±0.14[a]	6.29± 0.06[b]	1.64 ± 0.02[a]	16.75 ± 0.14[b]	177.06 ±1.82[b]

The values are presented as a mean ± standard deviation: The values of the same column with different letters are significantly different ($p \leq 0.01$). Kponan porridges (BKP), Kponan porridges with *T. triangulare* sauce without fish (BKPTT), Kponan porridges with *T. triangulare* fish sauce (BKPTTP)

3.3. Characteristics of the subjects

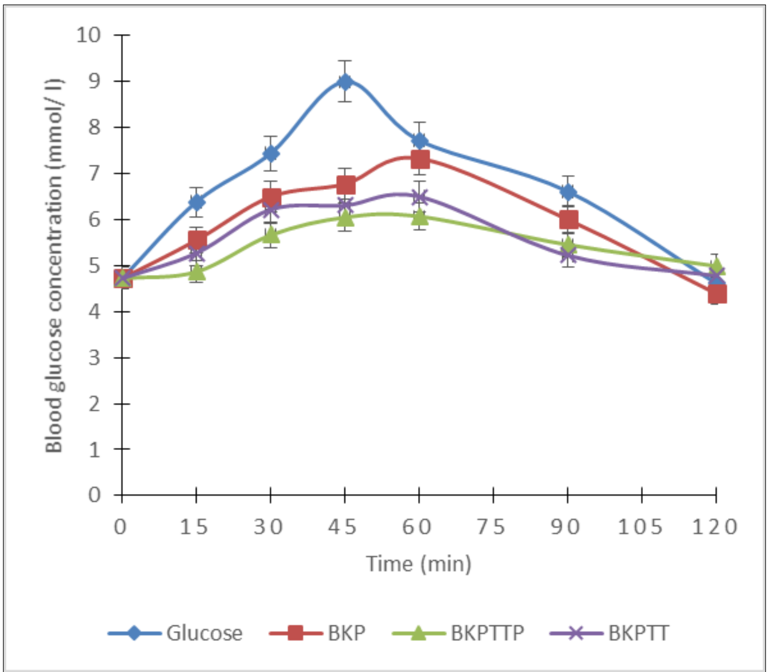
The clinical characteristics and anthropological parameters of the subjects are summarised in Table 3. Analysis of the results Twelve (12) [Sex ratio (M/F) = 8/4] healthy subjects aged 23.17 ± 5.5 years with a mean body mass index (BMI) of 20.63 ± 1.98 kg / m^2 were recruted. The fasting blood glucose level (4.71 ± 0.02 mmol/L) was normal (4.1 and 6.1 mmol/L) and the mean glycated haemoglobin level was 4.57 ± 0.01%. The metabolic pressures were 120.83 ± 3.5 mmHg for systolic pressure and 67.67 ± 5.56 mmHg for diastolic pressure.

Table 3 Descriptive characteristics of study participants at study entry

Parameters	**Values**	**Range**
Number of subjects	12	≥ 10
Gender (male/female)	8 / 4	
Age (years)	23.17±5.5	
BMI (kg·m2)	20.63±1.98	18.1–24.6
Fasting blood glucose (mmol/L) Glycated hemoglobin (%)	4.71±0.02 4.57±0.01	4.4-5.5 3.5-5.5
Systolic blood pressure (mmHg)	120.83±5.5	<130
Diastolic blood pressure (mmHg)	67.67±5.56	<80

3.4. Postprandial blood glucose of Kponan porridge and Kponan porridges with *T. triangulare* sauces

The postprandial blood glucose levels of the anhydrous glucose and the different meals evolved in two phases: a growth phase with a peak at 45 min for the anhydrous glucose and 60 min for the different meals, and a phase of progressive blood glucose decrease until 120 min. A significant difference between the postprandial kinetics of blood glucose levels induced by anhydrous glucose and different slurries. In the growth phase, anhydrous glucose produced the largest peaks with the highest peak (9.00 ± 0.03 mmol/L) obtained after 45 min. After anhydrous glucose, Kponan porridge without sauce induced a sharp increase in blood glucose from 4.72 ± 0.09 mmol/ L to 7.33 ± 0.18 mmol/ L (60 min) followed by Kponan porridge with *T. triangulare* sauce without fish and then Kponan porridge with *T. triangulare* sauce with fish The regression phase results in a decrease in blood glucose levels. Thus, postprandial blood glucose levels dropped from 9.00 ± 0.09 to 4.44 mmol/ L for the reference sugar (anhydrous glucose), 6.5 ± 0.22 to 4.8 ± 0.05 mmol/ L for Kponan porridges with *T. triangulare* sauce without fish (BKPTT) and from 6.07 ± 0.32 to 5.00 ± 0.02 mmol/ L for), Kponan porridges with *T. triangulare* fish sauce (BKPTTP).



Kponan porridges (BKP), Kponan porridges with *T. triangulare* sauce without fish (BKPTT), Kponan porridges with *T. triangulare* fish sauce (BKPTTP)

Figure 1 Postprandial blood glucose curves for Kponan porridge and porridges with *T. triangulare* sauces

3.5. Incremental Area under the plasma glucose curves (ASC), Glycemic index (GI) and glycemic load

The characteristics of the foods consumed are summarized in Table 3. The Incremental Area under the plasma glucose curves (ASC) of the reference food (glucose) is higher than those of the test foods. The ASC of yam porridges and porridges accompanied by sauces are between 80.58 ± 0.54 mrnol / L x 120 min and 124.46 ± 9.64 mrnol / L x 120 min. Kponan porridges (BKP) have the highest ASC (124.46 ± 9.64 mrnol / L x 120 min). Kponan porridges accompanied by sauce without fish have intermediate ASC while fish mixtures have weak ASC. The glycemic index (GI), it varies between 14.95 ± 5.71 (STTP) to 60.15 ± 4.66 (BKP). However, the glycemic index of sauces and porridges accompanied by sauces are lower than that of Kponan porridges without sauce. The glycemic load (Gl) of Kponan porridges (BKP) and Kponan porridges accompanied by sauces without fish is high (GL > 20) compared to the lowest of fish (GL ≤ 20).

Table 4 Area under the curve (ASC), Glycemic index (GI) and glycemic load

	ASC (mrnol / L x 120 min)	GI (%)		GL (%)	
Foods	**Mean ± S.D***	**Mean ± S.D***	**Classification**	**Mean ± S.D***	**Classification**
BKPTT	96.79 ± 4.74^{b}	46.79 ± 2.29^{b}	Low	23.39 ± 1.14^{b}	High
BKPTTP	80.58 ± 0.54^{c}	38.95 ± 0.26^{c}	Low	19.47 ± 0.13^{c}	Medium
BKP	124.46 ± 9.64^{a}	60.29 ± 4.66^{a}	Medium	30.08 ± 2.33^{a}	High
STT	ND	23.45 ± 7.24^{d}	Low	11.73 ± 3.62^{d}	Medium
STTP	ND	14.95 ± 5.71^{è}	Low	7.48 ± 2.86^{e}	Low

The values are presented as a mean ± standard deviation: The values of the same column with different letters are significantly different (p ≤ 0.01). *T. triangulare* sauce without fish (STT), *T. triangulare* fish sauce (STTP), Kponan porridges (BKP), Kponan porridges with *T. triangulare* sauces without fish (BKPTT), Kponan porridges with *T. triangulare* fish sauce (BKPTTP), ND not determined.

4. Discussion

This study provides information on the influence of sauces on the metabolic effects of the most widely consumed staple food in Côte d'Ivoire, through the determination of the glycemic index of the meal combinations for the glycemic effects in healthy subjects. Adding fat or protein to a carbohydrate meal also enhances insulin secretion even though the plasma glucose response actually decreases [18]. The biochemical and nutritional composition of *T. triangulare* sauces are shown in Table 1. After the statistical analysis, except, lipids and available carbohydrate, all of samples were significantly difference (p ≤ 0.05). The high fat, protein, fibers and polyphenols contents of *T. triangulare* sauce (STTP) and the good proportions of these nutrients are good nutritional qualities that could act as driving force for its consumption [19]. The table 2 shows the biochemical composition of tests foods. The Kponan porridge with *T. triangulare* sauce were higher in lipids, polyphenols, ash and total dietary fiber in comparison to the test foods. They naturally occurring in foods might reduce the rate of small intestinal digestion by delaying the penetration of the food by digestive enzymes. The high fiber content of this food underline their importance as sources of health benefiting nutrients in addition to being rich in carbohydrate and research evidence abound that link dietary and functional fibers to positive health outcomes . [20]. According to Henry et al. [21], 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. [22], 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 [23]. The postprandial blood glucose levels of the anhydrous glucose and the different meals evolved in two phases: a growth phase with a peak at 45 min for the anhydrous glucose and 60 min for the different meals, and a phase of progressive blood glucose decrease until 120 min. after consumption of anhydrous glucose and all of foods, there was an increase in blood glucose in all subjects. This increase in blood sugar is due to the assimilation and digestion of sugars ingested. Jenkins [24] have demonstrated this phenomenon through their numerous studies on the glycemic index. Thus, following the ingestion of sugars, several digestive enzymes including salivary alpha-amylase, pancreatic amylase, β-fructosidase, and galactosidase would hydrolyze sucrose and traces of starch into simple sugars. These are assimilated into the small intestine, leading to a significant increase in blood glucose [25]. The picks of the test food are reached at 60 min against that of the glucose is obtained at 45 min. This effect could be explained by the high fiber, proteins, fat, and polyphenols content of the meals. The high protein level would produce greater gastric inhibitory peptide (GIP) (known as glucose-dependent insulin tropic peptide) and 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 [26]. Thus, the sauce accompanying the rice meal would have an effect on the GI of the meal, since each component (carbohydrate protein-lipid) of a complex meal has a unique area located under the glycemic response curve. This could make considerable modifications to the hyperglycemic capacity of the meal [27]. The progressive regression of plasma glucose level after consumption of sugars is justified by the establishment of a system for restoring carbohydrate homeostasis. The accumulation of monosaccharide in the blood stimulates the pancreas, which secretes insulin to transport sugars into muscles and adipocytes. Indeed, the β-pancreatic cells secreted insulin which facilitated or increased the uptake of sugars consumed by the appropriate cells in the muscles, liver and adipocytes that will use them for the metabolism of the body. This justification is supported by the results of Wiedmeyer [28]. This is probably due to the addition of meat while cooking and to the presence of fat. Indeed, glucose responses of a food eaten alone or in combination with other foods differ. Adding fat or protein to a carbohydrate meal also enhances insulin secretion even though the plasma glucose response actually decreases. Moreover, all three primary macronutrients (carbohydrate, fat and protein) stimulate the release of several gut peptides, but to different degrees, and influence glucose effect. Protein and fat are particularly efficacious in stimulating gut peptide release despite a small direct glucose effect [29]. The addition of palm nut sauce and groundnut sauce had significantly beneficial effect on the carbohydrate regulation of the body since the glycemic index was relatively low (GI ≤ 55). The utility of using glycemic index in the management diabetes and certainly obesity. Although glycemic index presents some drawbacks, it may be useful in dietary prescription [30] as some studies have shown the efficiency of the consumption of low glycemic index meals in the management of diabetes, obesity and related diseases [30]. Indeed, there is evidence that low glycemic index diets are effective in improving glucose metabolism and insulin sensitivity as well as various markers of cardiovascular risk in people with diabetes and obesity and can be considered in the overall strategy of diabetes management [33]. According to Ludwig [33], low glycemic index foods would prevent inordinate rise in blood glucose levels, insulin spike, insulin resistance and consequently DM on prolong consumption. Glycemic load of Kponan porridges (BKP) and Kponan porridges accompanied by sauces without fish is high (GL > 20). However, those of fish sauces and accompanying sauces have medium glycemic load (11 ≤ GL ≤ 20). According to Mendosa [34], for a better control of glycemic response on diabetes mellitus management and its prevention, glycemic index data must be associated to glycemic loads data. The glycemic loads is a better indicator of how carbohydrate food would affect blood glucose than GI. In fact, it helps to select the appropriate portion (size or quantity) of a meal that is good for one's [9]. In this study, Kponan porridges (BKP), and boiled accompanied by sauces without fish meals have high GL (GL > 20 g). So, their consumption should be limited because they could increase the insulin response [3].

5. Conclusion

The work demonstrated that *T. triangulare* sauce affected the postprandial blood glucose response and glycemic index of Ivoirian staple foods. *T. triangulare* sauce should be preferred in the management of diabetes mellitus including individual who may be suffering from obesity.

Compliance with ethical standards

Acknowledgments

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Disclosure of conflict of interest

All the authors declare that they do not have any conflict of interest.

Statement of ethical approval

Ethical approval for this study was obtained from the ethical committee of NANGUI ABROGOUA University

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

References

[1] Asinobi C, Uzoagba H, Mba-Anyadioha A, N Lohnkennedy. Glycemic index of some traditional fortified staple meals on the postprandial blood glucose responses of Nigerian undergraduate students: an open-label study. Functional Foods in Health and Disease. 2016 ; 6(7): 414-424

[2] Flegal KM; Carroll MD; Ogden CL; LR Curtin, Prevalence trends in obesity among US adults, 1999–2008. JAMA 2010, 303, 235–241.

[3] Kouamé AC, Kouassi KN, Coulibaly A, N'dri YD, Tiahou GG, Lokrou A,. Glycemic Index and Glycemic Load of Selected Staples Based on Rice, Yam and Cassava Commonly Consumed in Côte d'Ivoire. Food and Nutrition Sciences. 2014 ; 5: 308-315

[4] Wolever TM, C Mehling. High-carbohydrate-low glycaem ic index dietary advice improves glucose disposition index in subjects with impaired glucose tolerance. Bristish Journal of Nutrition. 2002; 87:477-482.

[5] Kalergis M, Grandpre ED, C. Andersons. The role of the glycemic index in the prevention and managment of diabetes: A review and discussion. Can. J. Diabetes. 2005; 29: 27-38.

[6] Kouassi KN, Tiahou GG, Abodo FRJ, Cisse CM, AG N'guessan. Influence of the Variety and Cooking Method on Glycemic Index of Yam. Pakistan Journal of Nutrition. 2009: 8 (7): 993-999.

[7] Digbeu DY, Due AE, BROU K, Kouakou AM, Nemlin GJ, G Dago. Characterization of yam land races in Côte d'Ivoire with respect to food quality and end uses. Journal of Applied Biosciences 20: 1203 - 1214

[8] N'guessan AG, A Kamenan. Nutritional potential and traditional technology for processing amylaceous foodstuffs in Côte d'Ivoire. 2nd International Workshop. Food pathways to improving nutritional situations in West Africa: the roles of food and nutritionist technologies. 23-28, November 2003, Ouagadougou, Burkina Faso.

[9] Emaleku SA. 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. Journal of diabetes and metabolism. 2017; 8 (12): 1–7.

[10] Kouame AC, Kouassi KN, Coulibaly A, N'dri YD, Pereko KKA, Georges Tiahou GG, Lokrou A, N'guessani AG. Effects of Three Traditional Sauces Commonly Consumed in Côte d'Ivoire On Glycaemic Index of Rice Tested in Normoglycemic Adults. International Journal of Scientific & Technology Research. 2014; 3(1): 187-194.

[11] Amadi JAC, Asinobi CO, Okechukwu-Ezike NC, Aloy-Amadi O, Ihemeje A. Glycemic index and load responses of indigenous vegetable sauces among healthy young female adults. Functional Foods in Health and Disease. 2019, 9(9): 576-592.

[12] Association of Official Analytical Chemists (AOAC). Official methods of analysis. 15th ed.; Association of Official Analytical Chemists: Washington, DC, USA; 1990.

[13] FAO / WHO. Carbohydrates in Human Nutrition, FAO Food and Nutrition Paper 66. Report of an FAO/WHO Expert Consultation on Carbohydrates, April 14-18, 1997. Rome, Italy: FAO. 1998.

[14] Singleton V. L., Orthofer R. & Lamuela R. (1999). Analysis of total phenols andother oxidation substrates and antioxidants by means of Folin-Ciocalteu reagent. Methods Enzymology, 299: 152-78.

[15] Brouns F, Bjorck, KN, Frayn AL. Gibbs, Lang V, G. Slama, M. S. Wolever, "Glycaemic Index Methodology," Nutrition Research Reviews. 2005; 18 (1): 145-171.

[16] Schafer, G, Schenk, U, Ritzel, U, Romadori, G, U. Leonhardt. Comparison of the effects of dried peas with those of potatoes in mixed meals on postprandial glucose and insulin concentrations in patients with type 2 diabetes. American Journal of Clinical Nutrition, 2003; 78: 99–103.

[17] Salmeron, JE, Manson MJ, Stampfer GA, Colditz ALW, WC Willett. "Dietary Fiber, Glycaemic Load, and Risk of Non-Insulin-Dependent Diabetes Mellitus in Women. JAMA. 1997; 277(6): 472- 477.

[18] Atkinson S, Foster-Powell K, JC Brand-Miller. International Tables of Glycemic Index and Glycemic Load Values. Diabetes Care. 2008; 31(12): 2281-2283.

[19] Collier G, McLean A, O'Dea K. Effect of co-ingestion of fat on the metabolic responses to slowly and rapidly absorbed carbohydrates. Diabetologia. 1984; 26: 50–54.

[20] Omorigie ES, AU Osagie. Glycemic indices and glycemic load of some Nigeria foods. Pakistan Journal of Nutrition. 2008; 7: 710-716.

[21] Henry CJ, Lightowler HJ, Kendall FL, Storey M the impact of the addition of toppings/fillings on the glycaemic response to commonly consumed carbohydrate foods. European. Journal of Clinical Nutrition. 2006; 60: 763-769.

[22] Hätönen KA, Virtamo J, Eriksson JG, Sinkko HK, Sundvall JE, et al. Protein and fat modify the glycaemic and insulinaemic responses to a mashed potato-based meal. British Journal of Nutrition. 2011; 106: 248-253.

[23] Owen B, TM Wolever. Effect of fat on glycemic responses in normal subjects: A dose-response study. Nutr Res. 2003; 23: 1341-1347.

[24] Jenkins D., Wolever, T. and Taylor, H. Glycemic Index of Foods: A Physiological Basis for Carbohydrate Exchange. American Journal of Clinical Nutrition. 1981; 34: 362-366.

[25] Wiedmeyer CE, Johnson PJ, Cohn L.A, RL Meadows. Evaluation of a Continuous Glucose Monitoring System for Use in Dogs, Cats, and Horses. Journal of American Veterinary Medical Association. 2011; 223: 987-992.

[26] Pi- sunyer F. Glycemic index and disease. American Journal of clinical Nutrition. 2002; 76(1): S290- S298.

[27] Emaleku SA, Adepoju T, DO Olusola. Glycemic index and glycemic load determination of Ayoola and Endy Poundo yams consumed with Amaranthus hybridus (Tete) vegetable soup. Acta Scientific Nutritional Health. 2019; 3(2): 64-69.

[28] Wiedmeyer CE, Johnson PJ, Cohn LA, R.L Meadows. Evaluation of a Continuous Glucose Monitoring System for Use in Dogs, Cats, and Horses. Journal of American Veterinary Medical Association. 2011; 223: 987-992.

[29] Henry CJ, Lightowler HJ, Kendall FL, M Storey. The impact of the addition of toppings/fillings on the glycaemic response to commonly consumed carbohydrate foods. European Journal of Clinical Nutrition. 2006; 60: 763-769.

[30] Trout DL, Brotherhood JR, JC Brand-Miller: Predication of glycemic index for starchy foods. American Journal of Clinical Nutrition. 1993; 58: 873 – 878.

[31] Brand-Miller JC, Stockmann K, Atkinson F, Petocz P, G Denyer. Glycemic index, postprandial glycemia, and the shape of the curve in healthy subjects: analysis of a database of more than 1000 foods. American Journal of Clinical Nutrition. 2009; 89: 97–105.

[32] Bell KJ, Smart CE, Steil GM, Brand-Miller JC, King B, Wolpert HA. Impact of fat, protein, and glycemic index on postprandial glucose control in type 1 diabetes: implications for intensive diabetes management in the continuous glucose monitoring era. Diabetes Care. 2015; 38(6):1008–1015.

[33] Ludwig DS He glycemic index: Physiological mechanisms relating to obesity, diabetes and cardiovascular diseases. JAMA. 2002; 287: 2414-2423.

[34] Mendosa R. Revised International Table of Glycemic Index (GI) and Glycemic Load (GL) Values 2008, 127 p