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Impact of *Attieke*, *Attoukpou*, *Placali*, Three Dishes Based On Manioc, Currently Consumed In Cote D'ivoire, On The Glycemic Parameters In Rats

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ABSTRACT

Attiéké, attoukpou, placali **are three commonly consumed meals in Côte d'Ivoire, resulting from transformation of cassava. This study consisted in studying variations of the glycemic parameters which result from consumption of these foods in rat of strain *Wistar*. To do this we have determined the biochemical composition of these three foods. 15 rats were grouped into 6 groups. Each group received a food and glucose as reference food after a 12 h fasting. Blood glucose was taken from the tail vein at times 0, 15, 30, 45, 60, 90 and 120 min. Values were used to determine the glycemic index (GI) and GL of dishes. Biochemical analysis showed that *Attiéké*, *attoukpou*, *placali* are essentially composed of carbohydrate (more than 95% dwb) mainly starch. These dishes are produced from manioc, but attiéké GI (80) is significantly different and weaker than those of *attoukpou* and *placali* (106 and 102.1, respectively). In addition, *attiéké*, *attoukpou* and *placali* show significantly different glycemic loads (39.8, 48.2 and 22.9, respectively). These three foods are classified as high GI and GL foods; This is explained by their high content of carbohydrates of which they are constituted to more than 90% and the presence of gelatinized starch. The consumption of these foods in diabetic subjects can therefore prove to be dangerous because of their high glycemic index and load.**

Key words: Glycemic index, Glycemic load, Rats, Cassava meals and Diabetic subjects.

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INTRODUCTION

Diet and nutrition are important factors in promoting and maintaining good health at every stage of the human life cycle. Recently, rapid socio-economic changes, increased access to food, and urbanization have led to a "nutritional transition" characterized by a shift from primitive nutrition to more energetic and reduction of physical activity (Vorster et al., 1999; Popkin, 2004, 2006, 2009; Astrup et al., 2008). The nutritional transition is characterized by increased consumption of high-fat and energy-rich foods, processed sugar-rich foods, animal-based food products and decreased consumption of fruits, vegetables and whole grains (Popkin, 2001, 2006, 2009; Astrup et al., 2008). In Côte d'Ivoire, cassava, mainly the products resulting from its transformation, after fermentation, grinding and pounding, are highly energetic foods, which are part of the basic diet of the population. Cassava demand is higher in the South and Central than in the North, especially in large cities such as Abidjan, Bouaké. In these cities, demand is particularly rigid because cassava is part of the food habits and is consumed almost daily by the inhabitants, whether in the form of attiéké, placali or foutou (Perrin, 2015). The risk of this propensity to a high-energy diet is not negligible. Thus, the GI has clinically important advantages in preventing, and treating a number of metabolic diseases such as diabetes, cardiovascular disease (CVD) and certain forms of cancer and obesity (Jenkins et al., 2002; Brand-Miller et al., 2003b). Foods that are classified as low GI (Mendosa,

2000) give a better response to postprandial glucose, causing a slight increase in circulating levels of insulin and gastrointestinal hormones.

The dietary GI is an indicator of the quality of carbohydrates that reflects the effect on blood glucose and dietary glycemic load. It is an indicator of the quality of carbohydrates and the amount of food (Salmeron et al., 1997). Epidemiological evidence suggests that a high-glycemic diet or glycemic index may increase the risk of coronary heart disease (Liu et al., 2000; Ford and Liu 2001; Liu and Manson, 2001) and type 2 diabetes (Salmeron et al., 1997). *Attiéké*, *attoukpou* and *placali* three cassava-based dishes are essentially carbohydrate foods and therefore likely to raise glycemia considerably. The present study will therefore study the variations in glycemic parameters resulting from the consumption of these foods in rats.

MATERIALS AND METHODS

Food Material

The food material used in this work is the cassava variety IAC, cultivated in the sub-prefecture of Bonoua (a town in southern Côte d'Ivoire). The dishes studied are *attiéké*, *attoukpou* and *placali.*

Animal Material

The experiment was carried out on 15 male rats (Rattus norvegicus, Muridae) of *Wistar* strain weighing between 150 and 160 kg, from the animal facility of the UFR Biosciences of the Felix Houphouët-Boigny University of Côte d'Ivoire.

Methods of Preparing Meals

The three dishes were prepared by producers from the locality of Bonoua and transported to the laboratory for the various experiments. During the manufacture of attiéké, local producers proceed by washing and peeling the tubers of variety IAC (the IAC variety is used for the manufacture of the food), addition of ferment (the ferment consists of fresh tubers kept two to three days) with the previously peeled tubers, grinding, adding red oil discolored by heat, fermenting the dough for 12 h, dewatering the dough, sieving for obtaining a fine powder. The grains are formed by shaking and rotating the powder in a large bowl. The grains are sun-dried, fibers and dirt are removed. And then, grains are steam-cooked, packaging and preserving. The manufacture of attoukpou in the locality is carried out by washing and peeling the tubers of variety IAC (also called yace), addition of ferments (the same as that used in the preparation of the attiéké) grinding, salting, fermenting the dough for 12 h, dewatering and squeezing the dough, grains are formed by shaking and rotating the powder in a large bowl. And then, grains are steam-cooked, packaging and preserving. The manufacture of placali in the locality of Bonoua is carried out by the washing and peeling of the tubers of variety IAC, the addition of ferment with the tubers already peeled, the grinding, the fermentation of the dough for 12 h, dewatering and squeezing the dough, diluting the ground material in water, kneading, filtering, cooking the filtrate, conditioning and preserving the placali.

Biochemical Analysis

The moisture and ash contents were determined using the AOAC method (1980). Protein and crude fiber contents were determined according to the procedures mentioned by Pearson (1973). The fat was determined according to the procedures mentioned by Pearson (1976) using the Soxhlet method. Total carbohydrates and starch were determined by the formulas recommended
by **FAO** (1947): Total Carbohydrates = 100 - (% Moisture +% Lipids +% Protein +% Ash)
Starch Content = 0.9 (% Total Carbohydrate - % Total Sugars).

Determination of GI Of Food In Albino Wistar Rats

The rats were divided into three groups of five (5) animals, housed individually in metabolic cages, in a temperature controlled environment with free access to food and water. After three days of adaptation, the animals were weighed again after 12 h fast (fasting at night). The glucose level in the animals' blood was taken at time zero from the tail vein before feeding them with amounts of glucose calculated for each batch. First batch is constituted by rats receiving attiéké (lot ATT), second lot those which received attoukpou (lot ATO) and third lot those which received placali (lot PLA). Following the administration of the reference food (glucose) for each batch, the glucose of the animals was measured using an automatic glucose analyzer at 0, 15, 30, 45, 60, 90 and 120 min. One week later, the experiment was repeated by administering 2 g of attiéké to each of the rats of the ATT batch; 2g of attoukpou to those of the ATO lot and 2g of placali to those of the PLA lot. The carbohydrate value available for 2 g of each meal is similar to the amount of glucose administered for each batch of rats in the first experiment. The glycemic response will be determined as the incremental area under the blood glucose curve (IAUC) measured geometrically from the time-glycemic chart ignoring the region below the baseline). (Ijarotimi et al., 2015).

Measurement Of Glycemic Response

The blood glucose curves have been constructed from the blood glucose values of the animals at 0, 15, 30, 45, 60, 90 and 120 min depending on glucose and food samples consumptions. The incremental zone under the curve

Table 1. Macronutriments content* of food tested.

Settings	Dishes		
	Attiéké	**Attoukpou**	**Placali**
Humidity (g/100g fwb)	48.25± 0.05[a]	52.42± 0.47[b]	76.53± 0.01[c]
Ash (g/100g dwb)	0.45± 0.01[a]	0.43± 0.01[a]	0.41± 0.13[a]
Protein (g/100g dwb)	1.53± 0.05[a]	1.31± 0.03[a]	1.09± 0.01[a]
Lipids (g/100g dwb)	0.64± 0.05[a]	0.86± 0.05[b]	0.91± 0.05[b]
Dietary Fibers (g/100g dwb)	1.26± 0.03[a]	1.69± 0.15[b]	1.67± 0.04[b]
Total sugars (g/100g dwb)	1.44± 0.02[a]	2.94± 0.03[b]	1.11± 0.01[c]
Starch (g/100g dwb)	84.85± 0.01[a]	81.07± 0.02[b]	85.22± 0.01[c]
Carbohydrates (g/100g dwb)	96.1± 0.22[a]	95.68± 0.19[a]	95.9± 0.28[a]

*Values are mean ± SD of three data; * dwb: Dry weight basis; fwb: Fresh weight basis. [a. b. c. d.] Nutritional composition values for each food disposed horizontally and assigned different alphabet letters are significantly different.

different ; Newman-Keuls test, 5 %.
(AUC) will be calculated for the reference food (glucose) by the trapezoidal rule (Gibaldi and Perrier, 1982). The GI of each meal is calculated as the ratio between the incremental area under the curve below 2 h of glucose reaction in the blood for the food and the incremental area under the curve for the solution Glucose standard according to the method of Jenkins et al. (1981) Wolever et al. (1991), also taken up by FAO / WHO (1997) using the following equation:

$$GI = \frac{\text{Incremental area under 2h blood glucose curve for food samples}}{\text{Incremental area under 2h blood glucose curve for food samples}} \times 100$$

Calculation of the Glycemic Load (GL)

The GL for each food sample will be determined by the method of Salmeron et al. (1997) according to the following formula:

$$GL = GI \times (\text{Carbohydrate mass of portion / mass of portion})$$

Statistical Processing of Data

The statistical analysis is carried out by the software Statistica version 7.1. An analysis of variance is carried out and significance of the differences between means obtained from food samples is determined, with error risk of $\alpha \leq 0.05$.

RESULTS

Biochemical Composition Of Food

All foods analyzed were characterized by high water content. The moisture content of the placali (76.53 ± 0.01 g / 100g fwb) is higher than that of attoukpou and attiéké (P≤0,05). The levels of ash, carbohydrates, proteins from attiéké, attoukpou and placali are not significantly different (P>0,05). The placali is richer in starch (85.22 ± 0.02 g / 100 g dwb) than the other two dishes (P≤0.05). While attoukpou is richer in total sugars (2.94 ± 0.03 g / 100 g dwb) (P≤0.05), with a higher fiber value than attiéké (Table 1).

Glycemic Responses, Areas Under The Curve And Glycemic Index Of Foods

The blood glucose curves evolve virtually all in the same way. Indeed, they increase and reach a maximum value of 45 min after consumption of the foods tested or 30 min after administration of the reference food (Figures 1, 2 and 3). This phase is followed by a drop in blood glucose level, which is more or less rapid according to test food until the end of the 120 min. In all three cases, there was a significant difference between the area under the curve of the test food and the area under the glucose curve (reference food for each dish). In addition, the area under attiéké curve is less than the area under the curve of the reference food (glucose); The glycemic response of attiéké is therefore smaller than that of the reference food (Figure 1 and Table 2). On the other hand, the AUC (area under the blood glucose curve) of attoukpou and placali were higher than that of glucose. The AUC ranged from 190 to 244.7 mmol / min / L for the reference food, while the AUC of the tested foods ranged from 194.7 mmol / min (Placali) to 241.6 mmol / min / L (Attoukpou) (Table 2). The GI varied from 80 for the attiéké to 106 for the attoukpou. There is no significant difference between the attoukpou and the placali GIs. All three tested foods (attiéké, attoukpou and placali) were placed in the high GI food category. The GI varied from 80 for attiéké to 106 for attoukpou. There is no significant difference between attoukpou and placali GIs. All three tested foods (attiéké, attoukpou and placali) were placed in the high GI food category.

Glycemic Load of Feeds

With regard to the GL of these foods, there is a significant difference between the GL of the three meals tested.

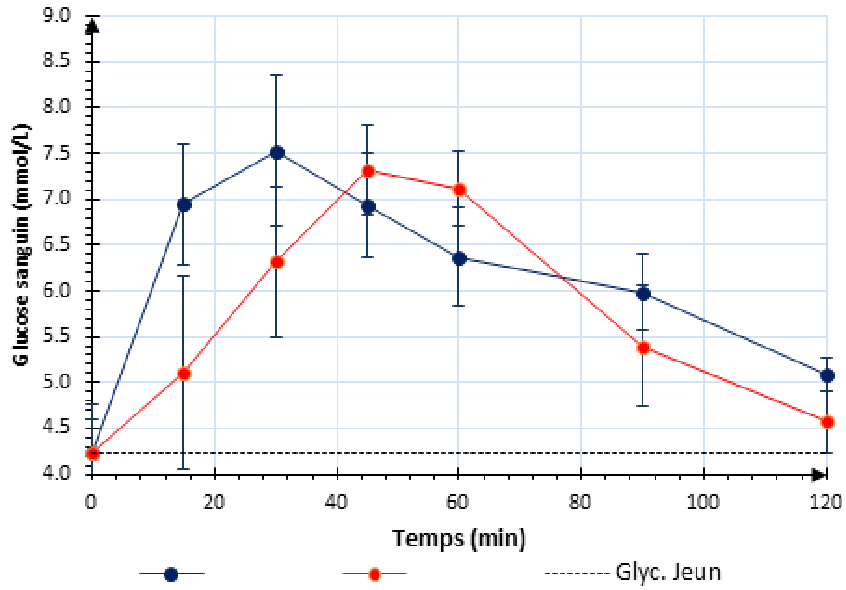

Figure 1. Influence of *attiéké* consumption on postprandial glycemic response. Blood glucose values are mean ± SD; (N = 5 rats); Blue curve: glucose; Red curve: attiéké.

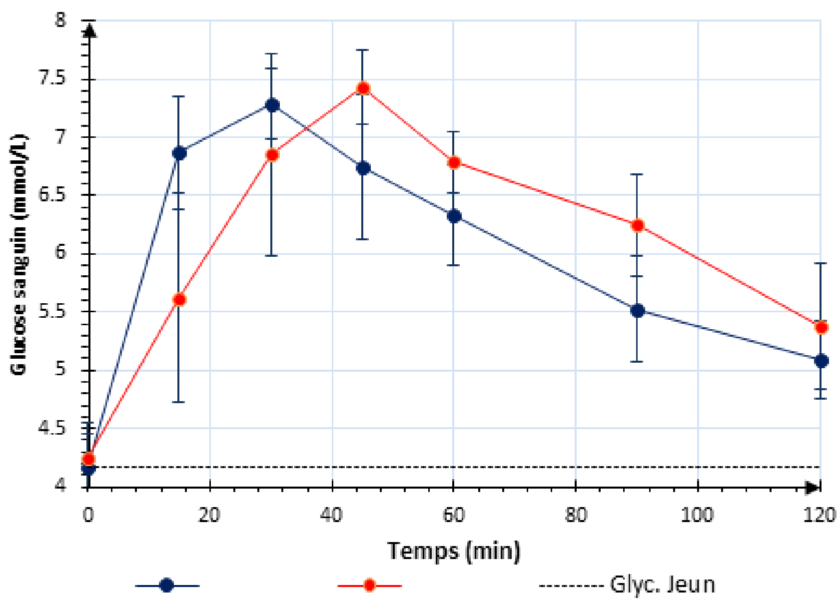

Figure 2. Influence of *attoukpou* consumption on postprandial glycemic response**.** Blood glucose values are mean ± SD; (n = 5 rats); Blue curve: glucose; Red curve: attoukpou.

Attoukpou has the highest GL (48.2), followed by attiéké (39.8). Placali has the lowest value (22.9). However, all three foods tested had GLs classified as high (Table 3).

DISCUSSION

Physico-chemical analyzes showed that the three foods studied were mainly characterized by high water content. These high levels of water could be explained in large part by the large quantities of water used in the preparation of these foods. Similar levels were observed in macronutrient composition of main staple foods consumed in Douala, Cameroon, where some culinary and food practices are virtually identical to those of Côte d'Ivoire (Sop et al., 2008).

The low lipid content of the tested foods is due to the relatively low lipid content of the tuber used. Indeed, starch products such as yam, cassava and plantain have always been considered to be low in fat (Amani and Kamenan

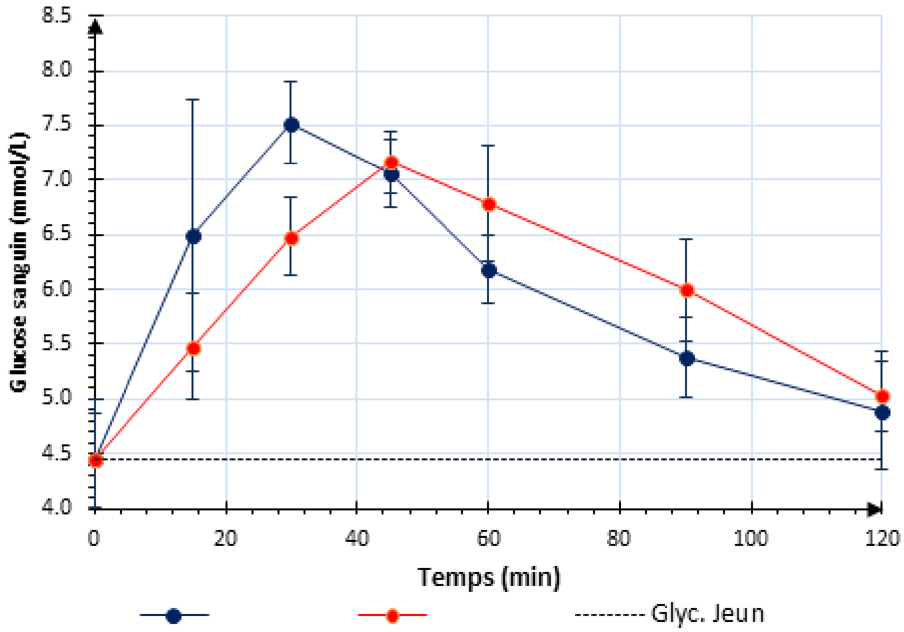

Figure 3. Influence of placali consumption on the postprandial glycemic response. Blood glucose values are the mean ± SD; (n = 5 rats). Blue curve: glucose; Red curve: placali.

Table 2. Area under curve (AUC).

Food tested	Ingested portions (g)	AUC-Glucose(mmol × min/L)	AUC-food (mmol × min/L)
Attiéké	2	244.7±27.4^{a}	195.8±30.5^{b}
Attoukpou	2	228.5±10.1^{a}	241.6±16.2^{b}
Placali	2	190.0±27.7^{a}	194.7± 40^{b}

$^{a.b.c}$ Mean values within a line with different exponent letters are significantly different (p <0.05) according to the Newman-Keuls test ; values are mean ± SD; (n = 5 rats); AUC: Area under the blood glucose curve as a function of time.

Table 3. Glycemic index and glycemic load of tested foods

Food tested	GI [1] (Glucose = 100) [3]		GL [2] (by ingested portion)	
	Mean ± SD	Classification	Mean ± SD	Classification
Attiéké	80 ± 8.4^{a}	High	39.8±4.1^{c}	High
Attoukpou	106±10.7^{b}	High	48.2±4.9^{b}	High
Placali	102.1±11.3^{b}	High	22.9±2.5^{a}	High

^{a,b,c} Mean values within a column with different exponent letters are significantly different (p <0.05) according to the Newman-Keuls ; values are mean ± SD; (n = 5 rats); GI: glycemic index; GL: glycemic load; [1] Level of glycemic indexes (GIs) classified as high (> 69), medium (56-69 inclusive) and low (<56); [2] Glycemic load (GL) levels classified as high (≥ 20), medium (> 10 and <20) and low (≤10); [3] glucose was used as a reference food and was defined as GI = 100.

2003, Avallone et al., 2008, Stadlmayr et al., 2012). Low levels of protein have also been reported by Zoumenou (1994) in her work on cassava tuber dishes. The foods tested were very high in carbohydrates. They accounted for 95 to 96% of the dry matter of each meal. These values were much higher than those reported by Sop et al. (2008) where their grades vary from 24 to 62%. The nutritional components likely to influence the digestion of *attiéké, attoukpou* and *placali* were variable in terms of their physicochemical composition. However, the particularity common to all these meals happens to be the carbohydrate rate. It represented more than 90% of the energy intake in the basic component of these meals. However, many studies report that eating more than 80% of energy intake from carbohydrates may induce metabolic disorders (Jenkins et al., 1981). Therefore, one of the main objectives of this study was to determine the GI and GL of the main traditional cassava-based foods consumed in Côte d'Ivoire.

The first methodological approach suggested a study of the evolution of postprandial glucose in healthy subjects after consumption of these food products. The data showed that the AUC-estimated plasma Glycemic Response (GR) associated with *attoukpou* (241.6 mmol × min / L) was the highest compared to *placali* and *attiéké* (194, 7 mmol × min / L, 195.8 mmol × min / L, respectively). These values, expressed as a percentage of the GR of glucose (reference food), made it possible to obtain GIs on average. Among the three food products tested, the lowest GI (80) was recorded in *attiéké* and highest in *Attoukpou* (106) and *placali* (101). These three foods were identified as high GIs according to the international classification of the GI (ISO / FDIS 26642: 2010; 2010). Due to their high carbohydrate content of more than 90% and the presence of gelatinized starch (the degree of gelatinization is determined by the free water content), these foods have been able to induce significant hyperglycemia according to the ingested food portions. These results corroborate the work of Kouamé (2016), which reports that *attiéké ayité* and *placali* are classified as high GIs. Traditional foods such as *amala* (yam tuber food, Dioscorea rotundata), *agidi* (maize food: Zea mays) and *eba* or *garri* (cassava tuber food: Manihot Usima) studied by Omoregie and Osagie (2008) in Nigeria also had high GIs between 82 and 99. Mahgoub et al. (2013) In Botswana also obtained high GIs from carbohydrate-rich foods prepared from wheat (GI = 103), maize (GI = 91), sorghum (GI = 92), millet (GI = 95) and vegetables (GI = 86, *morama* food). It is now well established that these high GI foods are known to produce a rapid and significant increase in blood sugar levels certainly due to their rapid digestion. They lead to a high absorption and a large amount of glucose in the bloodstream (Wolever, 2013 ; Bhupathiraju et al., 2014). According to GI as food quality indicator (Wolever, 2013), the majority of the foods studied here would therefore not be suitable or conducive to consumption in their form, especially for type 2 diabetics because these foods are highly hyperglycemic (ISO / FDIS 26642: 2010; 2010). These foods would therefore have mediocre properties on the physiology of the organism. The significant differences observed between the GIs of the foods would reflect the fact that they would have starches of different physicochemical characteristics. Indeed, Foster-Powell et al. (2002) point out that the primary differences between GI values are inherent in the botanical species whose starch has physico-chemical characteristics of its own. Furthermore, a particular processing method for a given food can also greatly modify its GI (Leeman et al., 2008). This is the case of *attiéké* (IG = 80) and *attoukpou* (IG = 106). These foods are both made from the same variety of cassava but are significate difference of IG. In the case of *attiéké* its relatively low GI could be due to the process of dewatering (a process allowing to eliminate as much water as possible), granulation and the process of drying in the sun. Indeed, the relatively low temperature of the drying process leads to a retrogradation phenomenon, which changes the conformation of the starch by making it more resistant during digestion (Tako et al., 2014). These results show the importance of the physicochemical properties of starch products, but above all the obligation to take into account the form of preparation of foods in the recommendations made to patients with diabetes.

CONCLUSION

The results of this work show that attiéké, attoukpou and placali are essentially composed of carbohydrate (more than 95 % of the dry matter) mainly starch. These three foods are classified as high GI and GL foods. Placali and attoukpou have the highest glycemic index and attoukpou the highest glycemic load. Placali, on the other hand, has the lowest glycemic load because of its low carbohydrate content. The consumption of these foods in diabetic subjects can therefore prove to be dangerous because of their high glycemic index and load.

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