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# Glycemic Index and Glycemic Load of Four Local Alcoholic Drinks of Benin

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***Authors' contributions***

*This work was carried out in collaboration between all authors. Authors MG, SAA and LBM designed the study, wrote the protocol and supervised the work. Authors MG, NA, HS and DS carried out all laboratories work and performed the statistical analysis. Author CV managed the analyses of the study. Author MG wrote the first draft of the manuscript. Authors SAA and LBM managed the literature searches and edited the manuscript. All authors read and approved the final manuscript.*

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## ABSTRACT

**Aims:** To identify glycemic index (GI) and glycemic load (GL) of four local alcoholic drinks of Benin in young and healthy adult subjects.
**Study Design:** An experimental study.
**Methodology:** After ethic advice, 40 voluntary subjects (24 men, 16 women), were selected among the students of the University of Parakou (Benin) and divided into 4 groups of 10. Each group of subjects consumed 100 mL of one of the four beverages (*tchoukoutou*, *sodabi,* fresh palm wine, fermented palm wine), alone and with 100 g of whole wheat bread (50 g of carbohydrates). The glycemic response for 2 hours was assessed based on plasma glucoses.

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**Results:** All the four drinks investigated had a low GI: *tchoukoutou* (20.59%), *sodabi* (18.34%), fresh palm wine (11.66%) and fermented palm wine (4.27%); but the GL were variable: *tchoukoutou* (68.77%), fresh palm wine (115.43%) and fermented palm wine (0.42%).
**Conclusion:** This study contributes to put in place a database of local resources for the prevention and management of some chronic diseases.

*Keywords: Alcoholic drink; glycemic index; glycemic load; palm wine; sodabi; tchoukoutou.*

## 1. INTRODUCTION

Jenkins et al. introduced the concept of glycemic index (GI) for classifying foods containing carbohydrates according to their propensity to influence glycemia [1]. Later, the concept of glycemic load (GL) had been introduced taking into account quality and quantity of carbohydrates contained in the foods [2,3]. GI is defined as the incremental area under the curve (IAUC) of glycemic response during two hours after intake of a test food compared to the area corresponding after ingestion of an equivalent amount of glucose as reference food (glucose or white bread) [4,5]. GL is a concept which embraces GI and carbohydrate content and is considered as representing the overall glycemic response of a food [6].

Recent studies showed that foods with high GL increase glycemia and insulinemia in human beings [2,7]. If foods with high GL are a protective factor against colorectal cancer in the woman [8], the premise that high GL would result in hyperinsulinemic hypoglycemia which would be responsible for the genesis of colorectal cancer [9] seems to be challenged. Risk for cardiovascular diseases increases with intake of foods with high GI and GL [10,11]. Foods with low GI and GL proved their ability to influence blood and urine parameters related to diabetes mellitus [12,13,14]. The concept according to which GI and GL would be risk factors for metabolic disorders encouraged researchers from various areas to establish food system data tables in industrialized countries. Therefore, it becomes necessary to assess the GI and GL of the different foods and drinks of each community.

Nowadays, the consumption of local alcoholic drinks has increased in Sub-Saharan Africa and particularly in Benin, due to their sociocultural character and their relatively low cost compared to industrial and imported drinks. Craft production of alcoholic beverages in Sub-Saharan Africa is based on almost identical traditional processes from one country to another [15,16] and their composition is variable according to the type of drink [16,17]. If it is a fact that ethanol has a hypoglycemic action [18], glycemic response after ingestion of an alcoholic drink depends on its content [19].

The GI and GL values of more than 2480 foods consumed globally were listed in the most recent editions of international tables of glycemic index and glycemic load [20], in which the foods consumed in Benin are not mentioned. Few studies were dedicated to GI and GL of the foods consumed in Sub-Saharan Africa [6,21,22]. In Benin, little is known about GI and GL of local alcoholic traditional drinks. This research work aimed to identify the GI and GL of four local alcoholic drinks made in Benin among young and healthy adult subjects.

## 2. MATERIALS AND METHODS

### 2.1 Study Target Population

Forty adult subjects (mean age estimated at 24.10±2.22 years) were recruited among the students of the University of Parakou (Republic of Benin). They were volunteers from different ethnic groups and from both sexes (24 men, 16 women) who occasionally consume alcoholic beverages, and with identical eating habits. Their average body mass index (BMI) was 22.32±3.64 $kg/m^2$. The subjects of this study were selected according to the following criteria: (1) healthy appearance, (2) absence of an on-going dietetic treatment, (3) nonsmoker, (4) not to be under any medication, (5) normotensive, (6) absence of glycoregulation disorder and of family history of diabetes mellitus, (7) not to be pregnant or not to breastfeed, as regards women, (8) not to suffer from hepatopathy or pancreatopathy, (9) be free of crasis disorders, and (10) not to have a personal history of peptic ulcer or gastritis. The subjects thus selected were distributed into four groups of ten, according to the use of human model for the purposes of a medical experiment based on WHO / FAO criteria for the implementation of study on glycemic responses

[4]: group 1 made up of seven (7) men and three (3) women for Study 1; group 2 consisting of seven (7) women and three (3) men for study 2; group 3 consisting of eight (8) men and two (2) women for study 3; group 4 consisting of six (6) men and four (4) women for study 4. Table 1 shows the general characteristics for the participants in the present study.

## 2.2 Beverages Tested

The drinks tested in this study were: *tchoukoutou* (local millet/sorghum beer) titrated with 3% of alcohol, *sodabi* titrated with 40% of alcohol, fresh palm wine titrated with 3% of alcohol and fermented palm wine titrated with 8% of alcohol [16,23,24]. The physicochemical properties of those drinks were previously reported by Gomina Assoumanou et al. [25].

## 2.3 Standard Food

The standard food used was whole wheat bread. We chose 100 grams of whole wheat bread (containing 50 grams of carbohydrates) spread with margarine (bought from *Vital Pharmaceutical Ltd. London-United Kingdom*) in order to get a reference for a 100% glycemic index.

## 2.4 Experiment and Testing

This experiment was conducted according to international recommendations on study of glycemic index [4,5]. The experimental or testing method used was the one previously described by Gomina Assoumanou et al. [25]. In brief, the selected subjects were fasted for 10 to 12 hours before the experiment and weaned from any alcohol consumption on the day before. Each of the 40 subjects was attended on the day of experiment in the room arranged for that purpose in the morning at 8 a.m. After 10 to 15 minutes of rest, a venous catheter was put in place in the ulnar veins to collect a blood sample (3 mL) enabling to get baseline blood glucose level. Then, after ingestion of those drinks, blood samples (3 mL) were collected through the catheter into tubes containing sodium and oxalate fluoride every 15 minutes during the first hour and then every 30 minutes as from the second hour. Each group of subjects has four sessions spaced one week apart. The first two sessions were dedicated to intake of 100 g of wheat bread spread with margarine and consumption of 250 mL of flat water during 10 minutes. The third session was dedicated to the consumption of 100 mL of different beverages tested on an empty stomach during ten (10) minutes. The fourth session was dedicated to the intake of the same quantities of tested beverages consumed on an empty stomach during ten (10) minutes with 100 grams of whole wheat bread spread with margarine.

## 2.5 Blood Glucose Level Measurement

The blood samples collected were centrifuged at 4000 rpm during 15 minutes to get plasmas. Glucose was measured in the plasmas thus obtained through enzymatic method based on end point titration of glucose oxidase-peroxidase by using kits from *Linear Chemicals* laboratory previously reported by Gomina Assoumanou et al. [25].

**Table 1. General characteristics of study population (n = 40)**

| Variables | | | Values | Reference values |
|---|---|---|---|---|
| Men / women | n/n | | 24/16 | |
| Age (years) | | Mean ± SD | 24.10±2.22 | |
| Systolic blood pressure (mmHg) | | Mean ± SD | 12.64±0.90 | < 130 |
| Diastolic blood pressure (mmHg) | | Mean ± SD | 84.30±0.60 | < 85 |
| Fasting plasma glucose (mmol/L) | | Mean ± SD | 4.11±0.48 | 3.89 – 6.11 |
| Urea (mmol/L) | | Mean ± SD | 3.08±0.48 | 2.49 – 9.13 |
| Creatinine (mmol/L) | Men | Mean ± SD | 97.65±4.39 | 61.09 - 123 |
| | Women | Mean ± SD | 72.88±3.25 | 53 – 106 |
| ALT (U/L) | | Mean ± SD | 28.01±10.13 | < 48 |
| AST (U/L) | | Mean ± SD | 19.08±7.49 | < 48 |

*AST: Aspartate amino transaminase, ALT: Alanine amino transaminase*

### 2.6 Calculation of Glycemic Index and Glycemic Load

The GI of each drink was calculated based on averages of incremental areas under the curve [26,27]. GL was obtained through the formula proposed by Granfeldt et al. [28] and John et al. [27].

### 2.7 Statistic Analysis

Quantitative data were analyzed with Office 2007 and SPSS Microsoft Excel softwares. Graphics were drawn with the same softwares. The data were presented in the form of ratios and averages ± standard deviations. Concerning calculated averages of areas under the incremental curve data were compared with analysis of variance (ANOVA) refined through Student t test. P value < 0.05 was considered as significant.

## 3. RESULTS AND DISCUSSION

This experimental trial helped us identify GI and GL of four local alcoholic drinks of Benin among young and healthy adult subjects. The four beverages tested alone or with bread had distinct glycemic index and loads.

FAO recommends testing reference food three times in each subject [5]. But recent studies suggest that no evidence justifies that the performance of three tests remains higher than two tests, for the difference between three and two tests is not significant [29]. In our study, reference food was tested twice to determine glycemic index and load.

Despite the existence of standard protocols recommended for the determination of GI [5,30], there are some methodological factors which may influence accuracy and precision in GI determination. According to a study conducted by several laboratories [26], foods' GI values are calculated with more accuracy by using capillary blood glucose (CBG) rather than plasma glucose. A study carried out by Hätönen et al. [31] found out that the coefficients of variation (CV) of incremental areas under the curves were significantly lower for capillary blood than for venous blood. However, some comparative studies of capillary blood glucose and plasma glucose recommend using plasma glucose to confirm capillary blood glucose values, especially when intermediate capillary blood glucose values exist [32]. In our research work, we used plasma glucose.

The averages of incremental areas under the curve obtained on an empty stomach in this research work regarding *tchoukoutou*, *sodabi*, fresh palm wine and fermented palm wine (Fig. 1) are significantly distinct from those identified by Brand-Miller et al. [19] in Australia ($p < 0.001$).

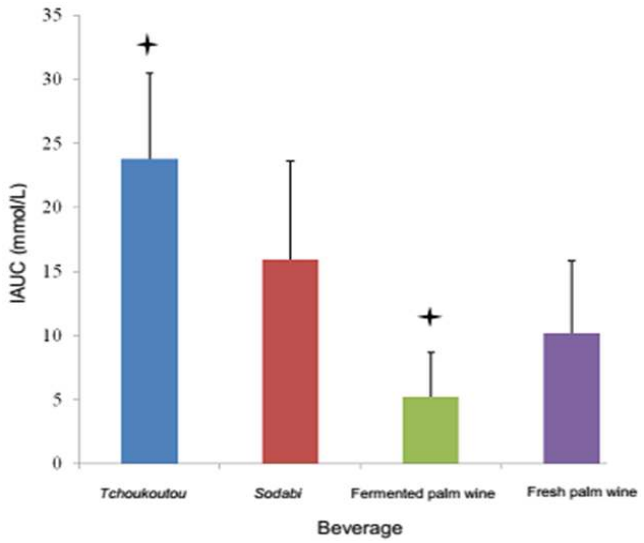


**Fig. 1. Averages (± standard deviation) of areas under the incremental curve of four investigated drinks consumed on an empty stomach**

*Significantly different (p = 0.024 through ANOVA refined by student test);*
*IAUC: Incremental area under the curve*

The differences observed in the values of incremental areas under the curves may be due to many reasons. The fasting lasted four hours in the study of Brand-Miller et al. [19] while it lasted twelve hours in ours; as well, Brand-Miller et al. [19] measured capillary blood glucose whereas we used plasma glucose. The presence of small amounts of quickly digestible carbohydrate, i.e. 13 g, in industrial beer [19] against 4 g in *tchoukoutou* [23], may contribute to increase significantly glycemic response as regards industrial beer. Moreover, the fundamental process of traditional beer production in West Africa is characterized by malting where starch is processed into simple sugar and then into acetic acid [33]; that process of acidification of the product would help reduce significantly glycemia [34]. Concerning fermented palm wine, the results obtained may be due to the difference concerning the origin of the wine. As a matter of fact, the local palm wine used in our research work was produced with the sap of *Elaeis guineensis* which is a typically tropical plant [35] whereas industrialized wine used in the study of Brand-Miller et al. [19] is the result of fermentation of various fruits.

Consumed with 100 g of bread, the averages of incremental areas under the curve of *tchoukoutou*, *sodabi*, fresh palm wine and fermented palm wine (Fig. 2) in our study are also significantly different from those encountered by Brand-Miller et al. [19] in Australia ($p < 0.001$).

In addition to the reasons forwarded in the previous paragraph to explain the differences observed between our results and those of Brand-Miller et al. [19], fresh palm wine which has the highest glycemic load may have caused « idiopathic postprandial hypoglycemia syndrome ». Indeed, the potential mechanism of that postprandial hypoglycemia reaction may be due to an excessive insulin release and/or a significant obstruction of hepatic glucose production in the postprandial period, induced by a dietary burden with excess glucose [36].

We pointed out in our study that reduction of glycemia in men was more significant than in women as regards consumption of fresh palm wine (Fig. 3). Brand-Miller et al. [19] got the same result with white wine. As far as fermented palm wine is concerned, our research work however showed that reduction of blood glucose levels was much more significant in women. Concerning *tchoukoutou*, it reduced more glycemia in men whereas *sodabi* reduces more glycemia in women. Studies carried out on rats [37] indicated that there is a difference in glycemic response between both sexes by specifying that female rats were more likely to have hypoglycemia than males. Even if in human beings that difference still needs to be proved, our study enables to claim that there is a different interpersonal susceptibility.

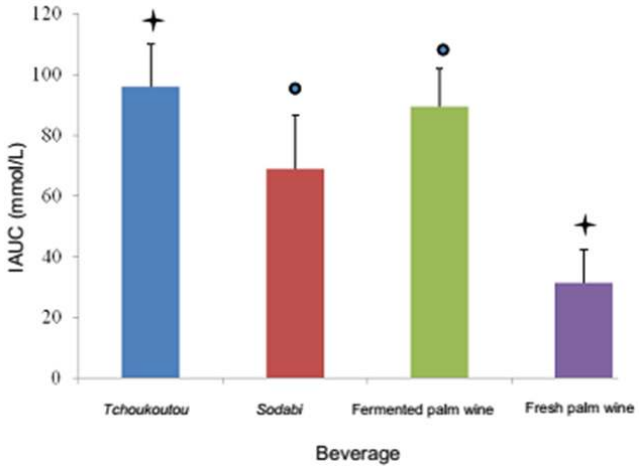


**Fig. 2. Averages (± standard deviation) of areas under the incremental curve of the four investigated drinks consumed with 100 grams of bread**

*Significantly different ($p = 0.017$ through ANOVA refined by student test)*
*Insignificant difference ($p = 0.087$ through ANOVA refined by student test)*
*IAUC: Incremental area under the curve*

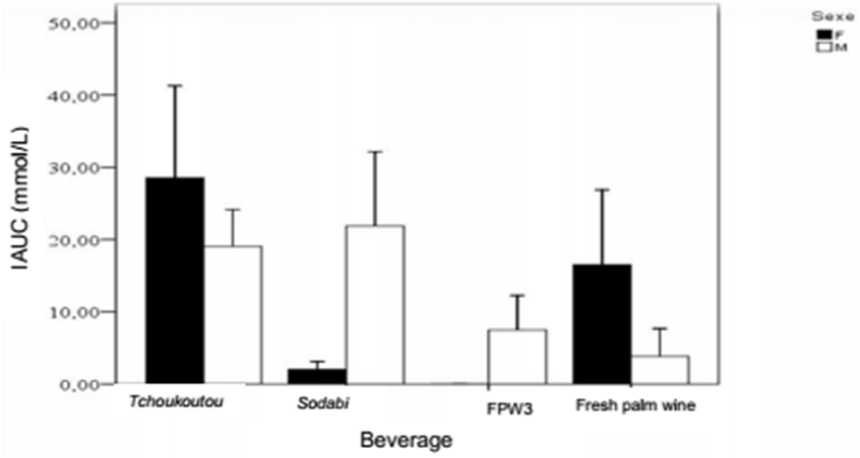


**Fig. 3. Averages (± standard deviations) of areas under the incremental curve of the four drinks investigated on an empty stomach, according to sex**

*VFE3: Fermented palm wine of study 3; IAUC: Incremental area under the curve*

In this investigative work, *tchoukoutou* had the highest GI whereas fresh palm wine had the highest GL (Table 2). If several research works were reported on glycemic index and loads of foods, we have no knowledge of studies performed on alcoholic drinks. For many years, interest for foods with low or moderate glycemic index had been mentioned in relation to diabetes mellitus [7]. Indeed, moderate glycemic responses in postprandial period are desirable for a good homeostasis of how human body works. All the drinks tested had low GI, ≤ 55% according to the classification of Foster-Powell et al. [6], without causing a real hypoglycemia (< 3 mmol/L) as pointed it out by a previous study [19]. However, fresh palm wine had the highest GL (115.43%) (Table 2).

**Table 2. Glycemic index and glycemic load of the four drinks investigated**

| | Glycemic index (%) | Glycemic load (%) |
|---|---|---|
| *Tchoukoutou* | 20.59 | 68.77 |
| *Sodabi* | 18.34 | USP |
| Fermented palm wine | 4.27 | 0.42 |
| Fresh palm wine | 11.66 | 115.43 |

*USP: Unspecified*

Although GI is used to classify carbohydrates' hyperglycemic potential, several factors such as food physical condition, particle size, cooking methods, presence of other macronutrients and structure of carbohydrates may modify foods GI [26,38]. According to Wolever [39], the addition of lipids and proteins to carbohydrates reduces postprandial glycemic response through several mechanisms such as acceleration of gastric emptying**.** Besides, for Petersen et al. [40], the addition of proteins in the carbohydrates may be an efficient way for reducing the impact of those foods. Nevertheless, several studies found out that the amount of proteins and lipids in commonly consumed foods does not influence glycemic response [41,42]. From another point of view, in addition to the known hypoglycemic response of ethanol [18,43], GI variability after alcoholic beverage ingestion depends on its content. Indeed, flavonoids in the wine reduce glycemic response by increasing insulin response [44,45]. Furthermore, the organic acids which may be produced during alcoholic drink fermentation process reduce GI through acceleration of gastric emptying [46] and inhibition of α-amylase activity [47,48]; as a result, there is a decline in the amount of free monosaccharide for intestinal absorption. Moreover, aminoacids derived from plants, particularly leucine, are hypoglycemic agents due to their insulinotropic character [49]. In this study we identified that the drinks used have a variable content of flavonoids, proteins and especially ethanol.

## 4. CONCLUSION

This research work has identified the GI and GL of four local alcoholic drinks commonly consumed in Benin among young and healthy adult subjects. All the four drinks tested have low glycemic index but variable glycemic loads. The

information generated by this study lays down the foundations for research on GI and GL of foods and drinks in Benin by enhancing previous research works. Therefore, its findings may contribute to put in place a database of local resources for the prevention and management of some chronic diseases.

## CONSENT

The subjects who participated to this study gave their free, informed and approved consent.

## ETHICAL APPROVAL

This research work was approved by the National Provisional Ethics Committee on Health Research in Republic of Benin (N°15-14/10/2010).

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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