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Chemical Composition and Glycemic Index Evaluation of Some Foods Consumed in Democratic Republic of Congo

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Abstract

The basic food consumed in Democratic Republic of Congo is mainly composed of rice, corn, cassava, millet, yam, plantain, sweet potato and sorghum. The objective of our study is to determine the mineral composition and glycemic index (G.I) of local food. We focus our study on the nutritional composition of minerals and the glycemic index of some basic food like tuber and grain of *Colocassia esculenta, Ipomea batatas, Oryza sativa* (Bumba and Sankuru), as well as a culinary preparation with cassava called "Malemba".The Bumba and the Sankuru rice are varieties of non-polished rice, produced locally in the north region (Bumba) and the central region (Sankuru) of Democratic Republic of Congo. The Malemba is the particular form of consumption of the cassava tuber specific to the Budja tribe in the Democratic republic of Congo. This receipt is made up with a white and cold paste obtained after different steps of preparation: cooking, weeding, steeping, grating then packing. The glycemic index has been determined by Jenkins method and the mineral composition by the fluorescence x Spectrophotometry. The results shown a glycemic index relatively nether for these foods: 22 % for Malemba, 44 % for the tubers of *Colocassia esculenta*, 37 % for the rice issue from Bumba and 41 % for the rice issue from Sankuru, 44 % for taro, index was mid with 54 % for sweet potato for the orange variety and 74 % for the white variety. We have seen that local foods contains some minerals elements like zinc, manganese, copper, vanadium and chromium which operate a key important role in glucids metabolism and insulin action. Bumba and Sankuru rice contains 5,1mg/100 g of copper; 0.7 mg/100 g of zinc; malemba preparation contains 0.429 mg/100 g manganese and chromium 21µg /100 g and 26 µg/100 g of vanadium.

Keywords: Diabete mellitus, local food, glycemic index, mineral elements

INTRODUCTION

The estimation made by the WHO in 2010, envisage that there will be 438 million diabetics patients by 2030, (WHO, 2010). These forecasts are based on the fact that four millions people died in 2010 from diabetes, either 6.8% of world mortality. Globally, there is an estimated 422 million adults living with diabetes in 2014, (Mathers and Loncar, 2006). The global prevalence of diabetes has almost doubled since 1980. This is due to the increase in risk factors associated as overweight and obesity,(WHO, 2016). That means a person dies because of diabetes every 8 seconds or 1,5 millions of world mortality in 2014. This is more than AIDS and malaria both, (Dye et al, 2016).

In sub Saharan Africa, the number of diabetic patients in 2011 was estimated at 14.7 millions with 737,090 of cases in the Democratic Republic of Congo (DRC) for the same year, (FID, 2013). Diabetes constitutes a public health problems in DRC. This requires a total implication of key actors of the health system to address this problem, (Lains, 2015).

The knowledge of the nutritional composition and the glycemic index of food permit diabetics to take food correctly in order to avoid the chronic metabolic complications. The glycemic index (G.I) measures the capacity of a given food to increase the glycemia after a meal taking compared to a standard reference which is plain glucose, (Marie,2015)

Foods are classified as high (GI ≥ 70), moderate (GI 56–69), or low GI (GI ≤ 55). Foods with a high GI are rapidly digested and blood glucose increases rapidly after consumption. Low GI foods in which starch is digested slowly show benefits in treatment of diabetes, weight control, improvement of satiety, and prevention of cardiovascular disease. As the rates of type 2 diabetes and obesity are increasing rapidly around the world, there is considerable interest in GI of foods in many countries, (Sidi and Miskelly, 2013).

The consumption of high-GI and -GL diets for several years might result in higher postprandial blood glucose concentration and excessive insulin secretion. This might contribute to the loss of the insulin-secreting function of pancreatic β-cells and lead to irreversible type 2 diabetes mellitus

Choosing low-GI foods in place of conventional or high-GI foods has a small but clinically useful effect on medium-term glycemic control in patients with diabetes. The incremental benefit is similar to that offered by pharmacological agents that also target postprandial hyperglycemia, (Marie 2003).

The glycemic index (G.I) for an amylaceous food is function of many parameters: amylase and amylopectin ratio; the technical and thermal treatment of the food; fiber and protein contents; the degree of ripening and ageing and mode of consumption, etc., (Michel , 2004).

The basic food for the human feeding, those providing more calories in the alimental ration and their use by diabetic soft causes debates between health care professional.

Several studies were made on local food in particular on the nutritional composition but these studies do not approach the index glycemic. (Augustin et al , 2015, Théophile , 2013)

Rice (*Oryza sativa*) constitutes the basic food stuff of more than half of the global world population. It can constitute a good source of energy, proteins, iron, calcium, thiamin, riboflavin and niacin, (Juliano 1994).

The taro (*Colocasia esculenta*) is less consumed. It can be boiled, fried or crushed in to cassava bread. The principal nutritive element provided by the tubers is energy by glucids. The taro is known as good source of potassium. (FAO)

The sweet potato (*Ipomea batatas*) has an economic advantage, but is frequently neglected. It is his enormous productivity in terms of dry matter and energy contribution, which exceeds that of other widespread basic food in her production zone,(Gura 1991).

Malemba is a kind of cassava consumption specific to one of the tribes of the DR Congo, called Budja. This receipt is a white and cold paste of cassava obtained after various steps of preparation: cooking, weeding, grating, steeping, and then package.

Recently, it was proven that certain mineral elements had a benefic influence on the action of insulin and the assimilation of glucose in the cells. The most quoted minerals reinforcing the action of insulin and the glucid metabolism are zinc, copper, chromium, manganese and vanadium, (Noel and collar , 2006).

Therefore, it is importance to determine the glycemic index and the particular mineral composition of our local food (taro, sweet potato, rice, cassava tuber), which is unknown by the population and some of care professional.

MATERIALS AND METHODS

Foods

We study foods produced locally: the taro (*Colocasia esculenta*), two varieties of sweet potatoes, orange and white (*Ipomea batata*), two varieties of rice (*Oryza sativa*) one from Bumba and other one from Sankuru and a culinary receipt called “Malemba”, a local preparation containing cassava tuber (*Manihot esculenta*).

The identification of our samples executed at the INERA herbarium which is located at the Faculty of Science of the University of Kinshasa (UNIKIN).

The analyses for the determination of the nutritional composition was executed by the laboratories of the Research center in Nuclear energy of Kinshasa (CREN-K).

The determination of the glycemic index was executed by the laboratory of Biochemistry of the Faculty of Pharmaceutical Sciences of UNIKIN.

Laboratory equipment

The muffle furnace Herbert Arnold 629-WEILBURG/LAHN-WERLSN
The steam OSK 9500C ELECTRONIC OVEN
Hotplate of brand OSK 84168 KJEDAHL
The fluorescence x spectrophotometer mark XEPOS III
Pastille machin mark WAPASH
The spectrophotometer Humalyser Primus Human 2000®

Chemicals and Kits

Proportioning of the glycemia:

Kit of glucose, mark CYPRESS DIAGNOSES made up of: Plug phosphates pH 7.4 with 13 mmol/l Phenol with 7.3 mmol/l Glucose oxydase to 11500 U/I Peroxidase to 750 U/I 4 - aminophénazone with 0.3 mmol/L Standard: aqueous glucose with 100 mg/dl.
Anhydrous dextrose, of brand SOLVAY
Protein proportioning: Sulphuric acid concentrate H_2SO_4 97%; Hydroxide of sodium NaOH 40%; distilled Water mixed Catalyst Na_2SO_4 + $CuSO_4$ + Selenium (50: 1: 1); Hydrochloric acid HCl 0,1N; Boric acid H_3BO_3 4%; neutral Indicator TASHIRO; composed of alcoholic solution of 0.1% and alcoholic solution blue methylene of methyl red 0.1% (1: 1)
Rough fibre proportioning sulphuric acid H_2SO_4 1.25%; Hydroxide of sodium NaOH 1.25%; distilled Water
Dosage of fat Ether of oil
Proportioning of the minerals Reference solution or standards of calcium, magnesium, sodium, cogitates, iron, copper, zinc, manganese, selenium, chromium, vanadium, iodine

Laboratory techniques

Moisture was determined by the principle of weight loss to drying followed by the weigh-in until a constant weight. (Working Party on Agricultural Quality Standards, 2002)
The proteins were proportioned by the method of KJELDHAL whose principle consists in oxidizing the organic matter by the boiling sulphuric acid in the presence of a catalyst, in fact the potassium and copper sulfate. (AOAC, 2002)
The lipids were obtained by continuous extraction with soxhlet. (Lane, 2004)
Fibers were determined by the method of Weende, the sample undergoes two consecutive attacks, of which the first use an acid and the second one use a base, both diluted.
The Glucids were determined by the difference in dry total weight with the weight of ashes, the lipids, proteins and fibers. (Nutrient, 2003)
Total ash was carried out by calcinations of the dry sample in oven at 450°C.
The mineral elements were proportioned by Spectrophotometry. (Rao and Xiang, 2009)

Foods preparation

All the food of study was boiled except the malemba which has undergoes several processes of treatment.

Experimental Design

The glycemic index was evaluated according to the method of Jenkins whose principle consists to administrate first the tested substance and then the reference substance (glucose) at the same individual in fast. The glycemia is initially determined in fast (GO) and then all 30 minutes after administration of food up to 180 minutes. The first day, we managed tested food equivalent to 50 g of glucids and the second day the reference substance. (Kenneth et al, 1990)
The glycemia of the subjects was determined by the enzymatic method with glucose oxydase by spectrophotometry. The calculation of the surface under the curve of food was obtained with the soft ware Auto CAD 2014. The glycemic index was calculated by submitting the ratio between the surface under the curve of tested food and that of the glucose multiplied by 100, (Jekins et al, 1981).

Statistical Analysis

The results are expressed at average ± ecart-type (±SD)

RESULTS AND DISCUSSION

Nutritional composition is presented as follows: table 1 presented the composition of macronutrients, table 2 the food macro elements composition, table 3 the food microelements and table 4 the glycemic index

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Table 1. The composition of macronutrients for studied local food expressed in % for 100 g of the dry matter

Parameters (%)	Orange sweet Potato	White sweet Potato	WhiteTaro	Bumba Rice	Sankuru Rice	Malemba
Moisture	58.3±0.088	62.4±0.046	74.1±0.060	0.1±0.012	0.1±0.008	86.3±0.127
Ashes	0.3±0.004	0.3±0.026	1.4±0.030	3.4±0.026	3.6±0.134	0.5±0.250
Proteins	3.6±0.012	4.1±0.012	3.7±0.020	7.6±0.124	7.5±0.120	0.1±0.140
Glucids	25.2±0.163	23.2±0.163	39.8±0.050	80.5±0.081	83.4±0.163	94.3±0.127
Fat	1.6±0.040	1.0±0.082	2.9±0.110	1.3±0.080	1.3±0.081	0.6±0.080
Fibers	11.0±0.408	**9.0**±0.081	2.3±0.410	7.0±0.000	4.0±0.000	4.5±0.270
Energy contribution in kCal/100g	129.6	118.1	196.6	364.1	375.3	382.9

The results on *Colocassia esculenta* are higher than those found by Ron B.H. Wills and al, with 74.1g against 65.1g of humidity/100g of taro. The proteins value is higher with 3.7g against 0.8g. The energy value is higher with AOAC, 20026.6 kCal against 128 kCal/100g. (Ron and collar1983, AOAC, 2002)

For the two varieties of sweet potatoes, the found values were compared with those of the Canadian File. The comparative analysis shows that the energy value of the orange variety (129.6 kCal) is higher than that of the white variety (118.1kCal). The energy value of two varieties is lower than that given by the file (134 kCal).

For proteins, it was noted that the two varieties have contents of proteins (orange variety 3.6g; white variety 4.1g) higher than that found in the file (2.4g).The same observation was made for food fibers and the lipids as indicated in table 1. As for glucids, we notice that the two varieties have values close but lower than that to the file (30.7g). (Canadian filer, 2010)

The two varieties of analyzed rice are compared with that of the brown rice (whole grain) found in the Canadian file. This study showed that the two varieties of rice have energy values close (264.1 kCal and 375.3 kCal) but largely higher than that found in the file (115 kCal).The content of protein of the two rices were 7.6g and 7.5g. Those values are higher than 2.7g. The content of Glucids is higher of 23.7g with 80.5g and 83.4g. The content of lipids with 1.3g for two varieties still is higher than 0.9g. The content of fibers of 4g and 7g correspond to more than the double. (Khalid and collarl, 2014)

Table 2 shows that the studied food contains the minerals in considerable quantity except Malemba which contains low level in these mineral elements except for Calcium. The two varieties of rice are richer in macro elements than other food subjected under investigation. The two varieties of rice contain the high level of Magnesium, important in the glucid metabolism.

Table 2. The composition in macro elements for studied local food expressed in % for 100 g of the dry product

Parameters mg/100g	Orange sweet potato	White sweet potato	Taro white	Rice Bumba	Rice Sankuru	Malemba
Calcium	60.67±0.72	50.2±0.04	85.38±0.05	1403.4±1.51	1406.5±3.21	181± 25.00
Magnésium	10.06±0.07	12. 06±0.05	26.1±0.03	102.1±2.58	104.0±0.22	5.81±0.62
Sodium	10.06±0.07	12. 06±0.05	26.1±0.03	102.1±2.58	104.0±0.22	-
Phosphore	51.38±1.60	50.38±0.53	56.59±0.20	178.3±2.90	184.1±1.63	17.05±0.20
Fer	$(7x10^{-3})\pm(5x10^{-4})$	$(5x10^{-3})\pm(0.5x10^{-5})$	0.87±0.06	10.2±0.06	12.1±0.08	3.60±0.32

Table 3. Microelements of studied local food expressed in % for 100 g of the dry product

Parameters mg/100g	**Orange sweet potato**	**White sweet potato**	**Taro white**	**Rice Bumba**	**Rice Sankuru**	**Malemba**
Copper	2±0.0004	1± 0.0004	160±0.0300	5100±0.4000	5100±0.0230	170±7
Zinc	5±0.0000	5 ±0.0004	6±0.4100	700±0.0210	700 ±0.0160	442±5
Manganèse	$4\pm4.71.10^{-5}$	$3\pm4.71.10^{-5}$	-	50 ±0.0090	50± 0.0090	429±36
Sélénium	-	-	-	0.1±0.0000	0.1±0.0000	-
Chrome	-	-	-	-	-	21±3
Vanadium	0.01±0.0000	0.01±0.0000	-	$0.36\pm4.71.10^{5}$	$0.36\pm4.71.10^{5}$	26±6
Iodine	-	-	0.1±0.0000	-	-	4.7±1,3

Our micronutrient values are compared with the results of the Nutritional Composition Table, CIQUAL 2013. Iodine was not found in sweet potatoes while the found values of zinc were higher with 5 µg for both varieties compared to 0.33 µg. The copper value is higher with 2 and 1 µg compared to 0.21 µg. The manganese present with values of 4 and 3 µg against 0.85 µg.

The preparation "Malemba" contains 0.43 mg of Manganese per 100 g. Chromium and Vanadium are present with 21mg/100g and 26mg/100g.

Both varieties of rice contain the most amount of magnesium and zinc. These two elements are involved in carbohydrate metabolism. They potentiate insulin action and influence the function of other enzymes, (Foster-Powell et al,2002). Some mineral elements could not be detected in our samples.

Table 4. The glycemic index of studied local food expressed in % for 100 g of the dry product

FOOD	**GLYCEMIC INDEX** in %
MALEMBA	22
RICE BUMBA	37
RICE SANKURU	41
TARO WHITE	44
ORANGESWEET POTATO	59
WHITESWEET POTATO	74
GLUCOSE	100

The results of table 4 show that all the studied food have low glycemic index (Malemba, Rice Bumba, Rice Sankuru and Taro White) except the two varieties of sweet potato.

The glycemic value of the taro index found in this study is close to that found by Foster Powell (43%) and lower than the found value of David Mendosa (48%).(David,2008, Ongnessek,2012) All these studies show that the taro has a low value of glycemic index.

The Sankuru and Bumba rice had respectively 41% and 37%. That contrasts with the results found by David Mendosa (58%) and those founded in the Canadian file for the brown rice (55%) (Canadian filer, 2010, Ongnessek,2012)

Malemba has the lowest index among all studied food, with 22%. This study shows the existence for a food of a correlation between its composition in minerals and its glycemic index. Indeed, Malemba and the various varieties of rice which contained the greatest contents of glucids, have a low glycemic index. What could be explained by their more important content of mineral influencing the glycemia. (as shown in tables 2 and 3)

The Glycemic Index of Malemba is lower than there found by S. Ongnessek Nengom et al. for the boiled cassava (75.2%).This difference is probably due to the mode of treatment of food. (Jennie et al 1997,AOAC, 2002)

The sweet potato orange variety has an moderate Glycemic index of 59 % while the white variety has a higher glycemic index 74%.We think that this difference is due to the fact that the orange variety has more food fibers than the white variety, so the rich fibers food have low GI. (Jennie,2014) This food should be in fact moderately consumed by the diabetics.

In a recent article published in American News paper of Clinical Nutrition(Lius,2010), there searchers compiled the studies carried out of AOAC, 2007 to 2010 on the link between the quantity of food which releases sugar quickly (high glycemic index) and the development of diabetes 2. They noticed that the link is direct and very strong. The consumption of foods with high GI increase the risk of diabete. What leads us to warn on the sweet potato consumption in order to reduce the risks of occurred of diabetes.

Another study of Sylvia F (2010) published in the news paper Diabetes care shown that the time of day to which the meal is taken has a great influence on the glycemia. Otherwise, the contributions of the breakfast have a greater influence on the glycemia to the diabetics type II. So sweet potatoes must outcast with the breakfast where as they are usually consumed at the morning by a part of the Congolese population. It would be necessary to moderate the feeding of foods with low index because the same study also shows that the diabetics type II with a low body mass index and height-waist ratio, are more sensitive to arise in the glycemia even in case of small sugar contribution, (Sylvia et al , 2010)

CONCLUSION

The analysis carried out show us that the local food: *Colocassia esculenta*, *Oryza sativa* (Sankuru variety and Bumba), Malemba receipt have a low glycemic index. The orange sweet potato has a moderate glycemic index and the white sweet potato has a high glycemic index. That enables us to affirm that low glycemic index food studied could be prescribed to diabetic. But for consumption of moderate glycemic index food could be consume by diabetics in the compliance with certain dietetics rules.

The minerals levels is significant in the two varieties of rice, especially for Iron, Zinc, Manganese, Copper and Selenium. The Chrome, Vanadium and Iodine are much more present in the Malemba. Some of these elements have a specific effect in the metabolism of glucids by accentuating the insulin effect.

This study must be continued for other local food. Also others works will help to establish the link between the mineral composition and glycemic index of foods. This will help to improve knowledge of health care professionals and all Congolese on the glycemic index and their link with the diabetes. Thus, we propose to the nutritionists to make a list of all local food with their glycemic index.

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