# Glycaemic Indices of Unripe Plantain (*Musa paradisiaca*) and Unripe Red Banana (*Musa sp. AAA*) Flour Meals

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***Abstract***

***This study determined the glyceamic indices of unripe red banana and unripe plantain flour meals. Unripe plantain and red banana were processed into flour and were subjected to proximate analysis using standard procedures. Twelve apparently healthy normo-glycaemic adults of normal body weight consumed 50 g digestible carbohydrate from glucose drink and test diets. Blood glucose concentration was measured prior to the consumption of the control and test diets and at 30, 60, 90 and 120 minutes after consumption of the standard and test diets. Glycaemic indices of the test diets were calculated. Data obtained were analyzed using descriptive statistics of SPSS version 16 and were presented as means and standard deviations. Unripe plantain and unripe red banana flours contained crude fiber (0.82% and 1.11%) and carbohydrate (85.85% and 86.77%), respectively. Glycaemic indices of unripe plantain and unripe red banana flour meals were 52.80 and 54.96, respectively.***

**Key words:** Unripe plantain flour, unripe red banana flour, glycaemic indices.

## Introduction

Diabetes mellitus is a chronic metabolic disorder that prevents the body from utilizing glucose completely or partially (Srilakslmi, 2011). It has become a global problem, a major epidemic of the millennium and one which shows no sign of abating (Thiam *et al*., 2006). The increasing prevalence rate of diabetes can be attributed to over-dependence on processed foods by the populace, physical inactivity and increase in overweight and obesity. Dietary manipulations are important in the management of type II diabetes (Augustin *et al.,* 2002). The major aim of using dietary therapy to manage diabetes is to achieve better glycaemic control.

Glycaemic index (GI) is defined as the incremental area under the blood glucose curve (iAUC) of a 50 g carbohydrate portion of a test food expressed as a percentage of the response to 50 g carbohydrate of a standard (reference) food taken by the same subjects, on a different day (Food and Agriculture Organization/World Health Organization, 1998). All food materials are not digested or absorbed at the same rate; hence, their glycaemic indices are different. Despite controversial beginnings, glycaemic index is now widely recognised as a reliable, physiologically-based classification of foods according to their post-prandial glycaemic effect (Foster-Powell *et al.,* 2002). Consumption of low GI food could be associated with a decrease in the risk of progression of diabetes and glucose intolerance (Eze *et al*., 2014).

Use of traditional diets has long been known to reduce the incidence of diet-related diseases such as diabetes. Studies have shown that locally available foods have different glycaemic index (GI) (Brown, 2005). Diabetics are sometimes faced with the problem of monotony in their dietary pattern as a result of limited range of foods to consume. There is scarcity of published information on the effect of various staple foods such as unripe plantain and unripe banana flour meals on glycaemic control. It was, therefore, necessary to explore the effect of flour meals from unripe red banana and unripe plantain on blood glucose of normo-glycaemic adults in order to provide insight on the potential of unripe red banana flour and unripe plantain flour for therapeutic purposes especially in the management of diabetes mellitus**.**

## Materials and Methods

### Sample preparation

Unripe plaintain *(Musa paradisiaca*) and unripe red banana (*Musa AAA)* were separately washed with tap water to remove contamination and dirt. They were peeled and sliced thinly (1mm thick). The slices were sun-dried for three days of 10 hours each day, which was milled into fine flour (1mm mesh) and stored separately in air-tight plastic containers.

**Proximate analysis**
The unripe plantain and unripe red banana flour samples were analysed for moisture, crude protein, crude ash, crude fat and crude fibre contents using the method of AOAC (2010). Carbohydrate content was determined by difference.

**Subjects**
Twelve apparently healthy normo-glycaemic adults (6 males and 6 females) between the ages of 20 and 29 years old were recruited from the Department of Home Science, Nutrition and Dietetics, University of Nigeria, Nsukka for the study.

**Anthropometric measurement**
Anthropometric measurements of weight, height, waist circumference and hip circumference were obtained from the subjects.

**Weight measurement:** Weight was measured using a bathroom scale. The subjects were asked to stand erect barefooted on the centre of the weighing scale without touching anything. Head, back and knees were held comfortably erect with arms hanging at the sides in a natural manner. The weight was read off and recorded to the nearest 0.5 kg.

**Height measurement:** Heights of the subjects were measured using a height metre. The subjects were asked to stand erect on a flat board, barefooted with their feet parallel to each other and their heels, shoulder and back of head held comfortably erect and both arms hanging at their sides in a natural manner. The head piece was lowered, crushing their hair and making contact with the top of their head. The height was read and recorded to the nearest 0.1 metre.

**Body mass index (BMI):** The BMI of the subjects were calculated using the subject's weight and height measurements as follows: BMI =

$$\frac{\text{Weight (kg}^2)}{\text{Height (m}^2)} = \text{Kg/m}^2$$

**Waist circumference measurement:** The waist circumference of the subjects was measured using a flexible non- stretchable tape. The subjects were asked to stand erect, abdominal muscles relaxed, arms at the sides and feet together on a flat surface. Waist circumference was measured above the iliac crest and below the lowest rib margin at minimum respiration. The waist circumference was read and recorded to the nearest 0.1 centimetre.

**Hip circumference measurement:** Hip circumference was measured using a flexible non-stretchable tape. The subjects were asked to stand erect, arms at the sides and feet together. The flexible non-stretchable tape was placed at the point of greatest circumference round the hip region. The tape made close contact with the body without indenting the soft tissue (leaving a mark on the body). The hip circumference was read and recorded to the nearest 0.1 centimetre.

**Waist-hip ratio** of the subjects was determined using the subjects' waist and hip circumference measurements.

**Preparation of the diet**
The quantity of flours that contained 50 g digestible carbohydrate was used to prepare the test diet. Unripe plantain flour meal was prepared by stirring continuously 64.91 g unripe flour in a pot of 75 ml boiling water until well-cooked to form a thick smooth brown paste. Unripe red banana flour meal was prepared using 61.15 g flour and 70 ml boiling water.

**Feeding of the subjects and blood glucose measurement**
Each subject consumed 50 g of glucose (control diet) reconstituted in 250 ml water on the first day of the study. Two days later, they each consumed 64.91 g of unripe plantain flour prepared into flour meal (test diet). Two days after consumption of the unripe plantain flour meal, the subjects each consumed 61.15 g unripe red banana flour prepared into flour meal (test diet). Fasting blood glucose of the subjects were measured prior to consumption of the control and test diets using an Accu–chek glucometer after a 10 – 12 hours post-absorptive fast. Blood samples were further obtained at an interval of 30, 60, 90 and 120 minutes after the consumption of the control and test diets.

Glycaemic indices of the unripe plantain and unripe red banana AAA flour meals were calculated as follows:

Glycaemic index =

$$\frac{\text{Incremental area under the curve (iAUC) of test food}}{\text{Incremental area under the curve (iAUC) of glucose}} \times 100$$

**Statistical analysis:** Data obtained were analysed using the computer program, Statistical Product for Service Solutions version 16. Data were presented as means and standard deviaton.

**Results and Discussion**

Table 1 shows the proximate composition of unripe plantain and unripe red banana flours. Unripe plantain flour had crude ash content of 2.80%, crude fibre content of 0.82% and carbohydrate content of 77.65%. Unripe red banana flour had crude ash content of 3.00%, crude fiber content of 1.11% and carbohydrate content of 77.59%.

**Table 1: Proximate composition of unripe plantain and red banana flours**

| Proximate Indices | Unripe plantain flour (%) | Unripe red banana flour (%) |
|---|---|---|
| Moisture | 12.71 | 11.37 |
| Protein | 5.49 | 6.28 |
| Ash | 2.80 | 3.00 |
| Crude fibre | 0.82 | 1.11 |
| Fats | 0.53 | 0.65 |
| Carbohydrate | 77.65 | 77.59 |

Values represent means of duplicate determinations

**Table 2: Mean anthropometric indices of the subjects (N=12)**

| Mean anthropometric indices | Male | Female | Group mean |
|---|---|---|---|
| Weight (kg) | 69.50 ± 9.40 | 55.00 ± 6.82 | 62.25 ± 10.89 |
| Height (m) | 1.73 ± 0.10 | 1.64 ± 0.08 | 1.68 ± 1.00 |
| Body mass index (kg/m$^2$) | 23.26 ± 1.12 | 20.00 ± 1.41 | 21.63 ± 2.10 |
| Waist circumference (cm) | 78.50 ± 4.09 | 77.50 ± 4.51 | 78.00 ± 4.13 |
| Hip circumference (cm) | 94.17 ± 2.23 | 97.17 ± 4.54 | 95.67 ± 3.75 |
| Waist-hip ratio | 0.83 ± 0.03 | 0.79 ± 0.01 | 0.81 ± 0.03 |

Results are expressed as means ±standard deviation

Table 2 shows the mean anthropometric indices of the subjects. Group mean body mass index, waist circumference and waist-hip ratio of the subjects were 21.63 ± 2.10 kg/m$^2$, 78.00 ± 4.13 cm and 0.81 ± 0.03.

The mean blood glucose level of subjects at different intervals (minutes) for glucose drink, unripe plantain and unripe red banana flour meals are shown in Figure 1. The mean blood glucose levels of the subjects 30 minutes after consumption of glucose drink, unripe plantain flour meal and unripe red banana flour meal were 124.70 ± 8.46 mg/dl, 105.70 ± 4.84 mg/dl and 110.60 ± 6.14 mg/dl, respectively. The mean blood glucose levels of the subjects 120 minutes after consumption of glucose drink, unripe plantain flour meal and unripe red banana flour meal were found to be 83.80 ± 3.32, 84.30 ± 2.04 and 86.30 ± 1.58 mg/dl, respectively.

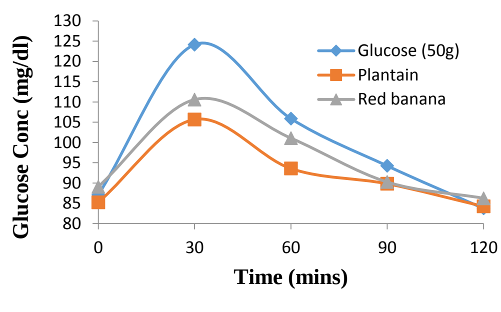


Figure 1: Mean blood glucose response curve before and after consumption of the control (glucose drink) and the test diets (unripe plantain flour meal and unripe red banana flour meal)

Table 3 shows the glycaemic indices of unripe plantain flour meal and unripe red banana flour meal. Unripe plantain flour meal and unripe red banana flour meal had glycaemic indices of 52.80 and 54.90, respectively.

**Table 3: Glycaemic indices of unripe plantain flour meal and unripe red banana flour meal**

| Sample | Glyceamic index (GI) |
|---|---|
| Unripe plantain flour meal | 52.80 |
| Unripe red banana flour meal | 54.90 |

The moisture contents of both flour is an indication that they have increased shelf-life, are less vulnerable to microbial attack and spoilage. Moisture content, used to measure the stability and susceptibility of foods to microbial contamination, was higher in unripe plantain flour than the 9.65 and 8.40 g reported by Abidoye *et al.* (2011) and Uzama *et al.* (2015). This variation could be attributed to the method of drying used by Abidoye *et al.* (2011) and the method of analysis used by Uzama *et al.* (2015). The method of processing of unripe plantain into flour may have contributed to the high moisture contents of 38.5 and 15.41 g earlier reported by Egbebi and Bademosi (2012) and Onuoha *et al*. (2014). Ogundare-Akanmu *et al.* (2015) reported similar moisture content (12.72 g) in one of the selected plantain flours sold in Port Harcourt market, Nigeria. Moisture content of the unripe red banana flour was higher than the 7.75 and 8.91 g reported by Ovando-Martinez *et al.* (2009) and Vernaza *et al.* (2011) probably due to the method of analysis. The high moisture content (14.31 g) reported by Asif-Ul-Alam *et al.* (2014) could be attributed to the processing method.

The low protein content of the flours is an indication that they were not good sources of protein. Any plant food that provides 12% of their caloric content from protein is considered a good source of protein (Ali, 2010; Effiong *et al.,* 2009). This was, however, not the case in this study. Unripe plantain flour had higher values than 4.54 g (Abidoye *et al.,* 2011), 2.8 g (Egbebi and Bademosi, 2012) and 2.23 g (Onuoha *et al*., 2014) earlier reported. These differences may be due to the methods of processing or varietal. Protein content of unripe red banana flour was higher than 3.19 g, 4.99 g and 4.43 g reported by Asif-Ul-Alam *et al.* (2014), Vernaza *et al.* (2011) and Ovando-Martinez *et al.* (2009), respectively. Varietal differences may, also, have contributed to this.

Ash content, which was almost similar to 2.43 g and 2.00 g reported by Onuoha *et al.* (2014) and Ayodele and Erema (2010) in unripe plantain flour, is an indication of the mineral content of the flours. Varietal difference may have contributed to the ash contents of 1.96 g and 3.80 g reported by Abidoye *et al.* (2011) and Egbebi and Bademosi (2012), respectively. The ash content of unripe red banana flour was almost similar to the 3.16 g reported by Vernaza *et al.* (2011) and lower than 2.67 g and 1.20 g reported by Asif-Ul-Alam *et al.* (2014) and Ovando-Martinez *et al.* (2009), respectively. Method of processing and analysis may have contributed to this.

The flours were not good sources of crude fibre. Fibre adds bulk to our diet, prolongs the presence of foods in the digestive tract thus providing greater satiety and increases fecal bulk. Crude fibre content of unripe plantain flour was higher than 0.7 g and 0.71 g reported by Egbebi and Bademosi (2012) and Onuoha *et al.* (2014). This may be due to the method of analysis used by Egbebi and Bademosi (2012) and the method of processing given to the flour (which may have been sieved by the traders after grinding) used by Onuoha *et al.* (2014). High fibre content of 1.83 g was earlier reported by Abidoye *et al.* (2011).

The low fat content of both flours is an indication that they may benefit those suffering from diet-related non-communicable diseases such as diabetes mellitus. The fat content of unripe plantain flour was similar to 0.50 g (Ayodele and Erema, 2010) but was lower than 0.75 g and 2.14 g reported by Abidoye *et al.* (2011) and Onuoha *et al.* (2014). The difference may be varietal. Lower fat content (0.2 g) was, however, reported in unripe plantain flour (Egbebi & Bademosi, 2012). Unripe red banana flour had higher fat content than the 0.50 g (Asif-Ul-Alam *et al.,* 2014), 0.36 g (Vernaza *et al.,* 2011) and 0.34 g (Ovando-Martinez *et al.,* 2009) earlier reported. This may be due to the variety or the method of fat analysis.

The high carbohydrate content of the flours recorded is expected since the food crops are starchy fruits and starch is the energy storage polysaccharide in plants. The carbohydrate content of unripe plantain flour was lower than the 83.1 g and 87.67 g reported by Abidoye *et al.* (2011) and Uzama *et al.* (2015). The method of processing of the plantain flour used by Abidoye *et al.* (2011) and the method of analysis used by Uzama *et al.* (2015) may have contributed to this.

Onuoha *et al.* (2014) reported almost similar (76.96 g) carbohydrate content. The method of analysis may have contributed to the low carbohydrate content of 54 g reported by Egbebi and Bademosi (2012). Varietal and soil difference may have contributed to the high carbohydrate content of 82.58 g and 80.80 g reported by Vernaza *et al.* (2011) and Asif-Ul-Alam *et al.* (2014), respectively in unripe banana flour.

Glycaemic index (GI) is a classification of the glucose-rising potential of carbohydrate foods relative to glucose (Wolever *et al*., 1991). Carbohydrate foods which raise the blood glucose level quickly after meal are regarded as high glycaemic index foods and have a value of 70 and above, whereas low glycaemic index foods which release glucose slowly into the blood stream have a value of 55 and below (Brand-Miller *et al.,* 2003). The glycaemic index of unripe plantain flour meal was lower than the 64.05% glycaemic index reported (Ayodele & Erema, 2010) for unripe plantain flour paste. Unripe plantain starches have only small concentrations of free sugars and rapidly digestible starch (Ramdath *et al.,* 2004). The amylose and amylopectin content of the unripe plantain flour meal may have contributed to the low glycaemic index. This was, however, not evaluated in this study. Unripe red banana flour meal had a low glycaemic index. This reveals that both unripe plantain flour meal and unripe red banana flour meal were low GI foods which reduce the post–prandial blood glucose level. Prospective studies support the therapeutic potential of low GI diets for hyperglycemia, improved insulin sensitivity and hyperlipidemia (Gilbertson *et al*., 2001). Clinical trials have shown that low glycaemic index diets improve glycaemic control in diabetes, increase insulin sensitivity, reduce food intake and body weight (Juntunen *et al*., 2003).They (low GI diets) are important in the management of hyperglycemia and hyperinsulinemia because they have high satiety effect and therefore can reduce the likelihood of excessive consumption of calories.

In conclusion, this study has demonstrated that unripe plantain (*Musa paradisiaca*) and unripe red banana (*Musa sp. AAA*) flour meals were low glycaemic index foods. There is need to encourage incorporation of unripe plantain flour and unripe red banana flour into snack recipes especially for those with diet- related chronic diseases and for more studies on glycaemic index of other staple foods so as to help the general public especially people living with diabetes mellitus and people at risk of diabetes mellitus to make informed food choices.

**Conflict of Interest**

There is no conflict of interest regarding the manuscript.

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