Asian Journal of Plant Sciences

ISSN 1682-3974

OPEN ACCESS
Asian Journal of Plant Sciences
ISSN 1682-3974
DOI: 10.3923/ajps.2020.412.418

Research article
Glycaemic Response and Sensory Attributes of Four Banana Varieties in Enugu State, Nigeria

[1]Aloysius Nwabugo Maduforo, [1]Dorcas Akachukwu Ogbuabo, [2]Chika Isabelle Ndiokwelu, [3]Clementina Ebere Okoro, [4]Chinyere Cecilia Okwara and [1]Elizabeth Kanayo Ngwu

[1]Department of Nutrition and Dietetics, University of Nigeria, Nsukka, Enugu State, Nigeria
[2]Human Nutrition and Dietetics Unit, Department of Biochemistry, University of Calabar, Calabar, Nigeria
[3]Nutrition Section, Federal Capital Territory Primary Health Care Board, Abuja, Nigeria
[4]Department of Nutrition and Dietetics, University of Nigeria Teaching Hospital, Ituku/Ozalla, Enugu State, Nigeria

Abstract
Background and Objectives: Glycaemic index of banana has been a burning issue among the populace to consider its suitability to be consumed by diabetic patients. Banana varieties commonly consumed in Enugu State have been considered to be similar in terms of their post-prandial effect without an empirical study that assessed their effect on the blood glucose. The study determined the glycaemic response and sensory attributes of four banana varieties consumed in Enugu State. **Materials and Methods:** Ten healthy human subjects participated in the glycaemic response study for each banana variety. The glycaemic response was evaluated using standard methods. Thirty judges from the Department of Home Science, Nutrition and Dietetics evaluated sensory attributes of the banana varieties using a 9-point hedonic scale. Descriptive statistics were used to describe the data obtained. One-way Analysis of Variance was used to compare the means of the glycaemic level and sensory evaluation scores of the banana samples. Post-Hoc analysis was done with the turkey HSD test. Statistical significance was considered at $p<0.05$. **Results:** Subjects recruited for glycaemic response study had a mean age of 23 years and mean BMI was 21.82 kg m^{-2}. The available carbohydrate content of Gros Michel was 6.19 g/100 g, Red Dacca was 6.29 g/100 g, Lady's Finger was 4.29 g/100 g and Green Mutant was 5.63 g/100 g. The glycaemic response of all the banana varieties was comparable ($p>0.05$) after 120 min. The glycaemic index of Gros Michel was 52, Red Dacca was 24, Lady's Finger was 45 and Green Mutant was 71. Glycaemic load of banana varieties was Gros Michel (3.22), Red Dacca (1.52), Lady's Finger (1.91) and Green Mutant (3.99). The sensory evaluation result of the four varieties of banana showed that Red Dacca was rated highest in general acceptability. The glycaemic index of the banana varieties studied shows medium glycemic index except for the Green Mutant variety, low glycaemic load and moderate glycaemic response. **Conclusion:** Banana could be consumed by all individuals including diabetic patients as the glycaemic index showed low to medium level. The Red Dacca variety could be used in the prevention and management of diabetes and should be recommended to overweight, obese and diabetic individuals.

Key words: Gros michel, Red Dacca, lady's finger, green mutant, banana, glycaemic response, management of diabetes, sensory evaluation

Citation: Aloysius Nwabugo Maduforo, Dorcas Akachukwu Ogbuabo, Chika Isabelle Ndiokwelu, Clementina Ebere Okoro, Chinyere Cecilia Okwara and Elizabeth Kanayo Ngwu, 2020. Glycaemic response and sensory attributes of four banana varieties in Enugu State, Nigeria. Asian J. Plant Sci., 19: 412-418.

Corresponding Author: Aloysius Nwabugo Maduforo, Department of Nutrition and Dietetics, University of Nigeria, Nsukka, Enugu State, Nigeria

Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Banana is a highly consumed fruit coming second after citrus and contributing about 16% of the world's total fruit production[1]. In Africa, annual production is estimated[2] at 19 MM t. Though banana varieties are one of the most important commercial crops in the world, 87% of total production is for local consumption[3]. In developing countries, banana is valued as the fourth most important crop after rice, maize and wheat to about 400 million people in the underdeveloped and developing countries of the world and as such contributes to a rich source of energy and nutrients[3]. Carbohydrate plays an important role in human diet contributing 45-65% of total calories[4], with healthy moderately active adults requiring 130 g of carbohydrate daily[4] to sustain brain metabolism and muscle function[5]. The rate of digestion and absorption of carbohydrate in food is dependent on factors such as its protein, fat and fiber content, the physical form of the food and the chemical structure of the carbohydrate[6]. This suggests that the carbohydrate effect on blood glucose levels varies according to the type of food consumed.

The glycaemic response is the effect that carbohydrate-containing food has on blood glucose concentration after consumption[7]. Several tools have been developed to help quantify and communicate the effect of food on glycaemic response. These include invaluable tools such as glycaemic index (GI)[8], glycaemic load (GL) and glycaemic glucose equivalents (GGE)[9]. The glycaemic index method was developed to determine the effect of equal carbohydrate portions of different foods on postprandial glucose[10]. Reference food can be either glucose or white bread. Foods are categorized based on their GI values into three: the high GI foods ($\geq$70), intermediate-GI foods (>55-<70) and low-GI foods ($\leq$55)[11]. Glycaemic load account for how much of carbohydrate is in the food and how each gram of carbohydrate in the food raises blood glucose and insulin levels[6]. GL is classified as low ($\leq$10), intermediate (11-19) and high ($\geq$20). GL is a metric used as a basis for weight loss or diabetes control[12].

A low glycaemic diet has been associated with a decreased risk of nutrition-related non-communicable diseases[13]. Dietary carbohydrates could elevate blood glucose levels, especially in the postprandial state. Therefore, for people living with type 1 or type 2 diabetes, a carbohydrate-rich food could be detrimental to glycaemic control resulting in complications such as diabetes-related amputations, neuropathy, retinopathy, nephropathy and coronary artery disease[14,15]. The incidence of type 2 diabetes accounts for more than 90 to 95% of all cases of diabetes mellitus with its associated economic stress on the health care system [16]. Several factors associated to this include: increase in a sedentary lifestyle, obesity, lack of physical activity, consumption of energy-rich diet, longer life span and smoking[17].

Several kinds of research have been published indicating the glycaemic response of banana varieties[18-20]. However, reports are scarce on the glycaemic response of banana varieties consumed in Enugu state. This study determined the glycemic response and sensory attributes of selected banana varieties widely consumed in Enugu State.

MATERIALS AND METHODS

Study area: The study was carried out in the Department of Nutrition and Dietetics, University of Nigeria Nsukka, Nigeria in July 2018.

Study design: The study adopted the experimental design.

Procurement and identification of samples: Four banana varieties were selected for the study and purchased from Ogige and Afor Opi markets in Nsukka Local Government Area, Enugu State, Nigeria. The banana samples were identified at the Department of Plant Science and Biotechnology of the University of Nigeria, Nsukka as Gros Michel (*Musa acuminata* AAA group), Red Dacca (*Musa acuminata*), Lady's Finger and the Green Mutant.

Determination of available carbohydrates: The phenol-sulphuric acid method was used to determine the available carbohydrate content of the banana varieties[21].

Ethical clearance: Ethical clearance was obtained from the health research ethics committee of the University of Nigeria Teaching Hospital (UNTH) Ituku-Ozalla, Enugu State before the study commenced.

Subjects: Normoglycaemic undergraduate students constituted the population of the study. A calibrated wooden stadiometer (improvised) was used for height measurement. Height measurement was taken with subjects' standing erect on bare feet (removing their shoes), arms relaxed by the sides, with head raised and face straight, buttocks and heels touching the flat surface of the improvised standiometre[22]. The reading was taken to the nearest 0.1 cm. The value from height measurement and age of respondents were keyed into the bi-electric impedance analysis machine which then took their weight, visceral fat, body fat, muscle mass, resting metabolic rate, biological age and body mass index, respectively

Sampling procedure: Advertisement on the research was done in the department of Nutrition and Dietetics, Faculty of Agriculture, University of Nigeria, Nsukka. Volunteers were asked questions on general eligibility. Eligible subjects were informed of the purpose of the study, the rules that would serve as a guide when the study commences, their right to withdraw and assurance of the confidentiality of information volunteered. Sixteen normoglycaemic undergraduate students aged between X and Y years with body mass index of between X and Y kg m^{-2} were enrolled in the study based on an exclusion criterion.

Procurement of reference food and medical materials: Glucose and medical materials such as a glucometer, test strips, lancets were purchased at the Ogbete main market in Enugu. Cotton wools, methylated spirit and water were purchased at pharmacy stores in Nsukka.

Preparation of test meals: Ripe banana fingers were served to the subjects without the use of fried peanuts as popularly consumed in Nigeria. This is because some factors like fiber, fat, protein and processing techniques affect the glycaemic index of foods[23].

Glycaemic response determination: The glycaemic response was determined by the method described by FAO/WHO[24]. The reference food was provided in portions equivalent to 50 g available carbohydrate. Fifty grams of glucose dissolved in 250 mL of water served as the reference food for the subjects. Ten normal subjects were studied on multiple occasions in the morning after a 12 h overnight fast. Subjects were asked to abstain from vigorous activities on the day before the test. The subjects were also asked to abstain from alcohol and smoking for 24 h before the test. Different quantities of the banana varieties that would supply 25 g of available carbohydrates were separately given to the subjects to consume on each day of the test because the quantity that would supply 50 g of available carbohydrates for each banana variety was too much for the subjects to consume within[24] 10 min. The quantity of banana that supplied 25 g of available carbohydrates that was fed to each subject in each group was 404 g for Gros Michel, 398 g for Red Dacca, 601 g for Lady's Finger and 444 g for Green Mutant. Fasting blood glucose and postprandial glucose level were measured at 30 min interval for 2 h using Gluco Spark glucometer. A day interval was allowed for each subject before the next test. This was to prevent carryover effect[24]. Subjects were advised to remain seated to avoid physical activity[14,24,25].

Glycaemic index and glycaemic load determination: The glycaemic index (GI) for each test meal for all the subjects were calculated as[14,24–26]:

$$GI = \frac{\text{IAUC of test food}}{\text{Mean IAUC of standard food}} \times \frac{100}{1}$$

where, IAUC is Incremental Area Under the blood response curve for the tested meal.

Data collected on the glycaemic index was coded and means and standard deviation were calculated. Glycaemic index classification according to standards[14,24–26]:

- High : 70-100%
- Medium : 56-69%
- Low : $\leq$35%

Glycaemic load (GL) was calculated with the formula[6]:

$$GL = \frac{\text{GI of food} \times \text{Amount (g) of available carbohydrate food per serving}}{100}$$

where, Glycaemic load was graded according tostandard[6,27]:

- High : $\geq$20% or above
- Medium : 11 or 19%
- Low : $\leq$10%

Sensory evaluation

Development of instruments for sensory evaluation: A nine-point hedonic scoring form ranging from like extremely to dislike extremely (9-like extremely, 1-dislike extremely) was developed to serve as an instrument for the sensory evaluation. The scoring ranged from like extremely, like very much, like moderately, like slightly, neither like nor dislike, dislike slightly, dislike moderately, dislike very much to dislike extremely[28]. The evaluated sensory properties included: color, flavor, taste, texture/mouthfeel and general acceptability[29].

Panel selection: Thirty panelists involving students selected from the Department of Home Science, Nutrition and Dietetics, University of Nigeria Nsukka were recruited for the sensory evaluation.

Sample presentation: The four samples were presented to the panelists in plate dishes appropriately labeled with codes: A, B, C and D for Gros Michel, Red Dacca, Lady's Finger and the Green Mutant respectively. Water at room temperature was provided for each of the panelists to rinse his mouths before and after tasting each sample to avoid the carryover effect of the test.

Statistical analysis: Statistical analysis was carried using IBM SPSS statistics software version 22. Descriptive statistics (mean and standard deviation) were used to describe the data obtained. One-way Analysis of Variance (ANOVA) was used to compare the means of the glycaemic response area and sensory evaluation result of the banana samples. Post-Hoc analysis was done with turkey HSD. $p<0.05$ was considered statistically significant.

RESULTS

Table 1 shows the available carbohydrate, GI and GL of the banana varieties studied. Available carbohydrate ranged from 4.29 g/100 g in Lady's Finger to 6.29 g/100 g in Red Dacca. Lady's Finger variety significantly ($p<0.05$) had the least available carbohydrate while the available carbohydrate in Red Dacca (6.29 g/100 g) and Gros Michel (6.19 g/100 g) were comparable ($p>0.05$). Green Mutant has the highest GI value of 71% while Lady's Finger has the lowest value of 24%. Red Dacca has the lowest GL value of 1.52% while Green Mutant has the highest value of 3.99%.

Table 2 shows the anthropometric indices of the subjects. The age range of the subjects was 19-32 years. The mean weight and height of the subjects were 23.46±3.36 kg and 170.38±10.29 cm. Body mass index (BMI) was 21.82 kg m^{-2}.

Table 3 shows the glycaemic response of the banana varieties under study and their values for glucose drink. The table shows that the peak value (148 mg dL^{-1}) was attributed to the glucose drink at 30 min. Green Mutant variety had the lowest postprandial blood glucose response at 30 min. At 120 min, Gros Michel banana had the lowest effect (94 mg dL^{-1}) on the postprandial glucose level.

The glycaemic response of the banana varieties consumed in Enugu State is represented in Fig. 1. Subjects that consumed the Green mutant banana variety had the highest mean value (101 mg dL^{-1}) at the end of the study (2 h

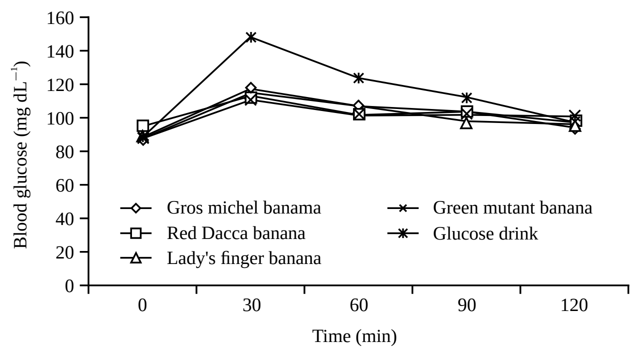

Fig. 1: Glycaemic response of banana varieties consumed in Enugu State

Table 1: Available carbohydrate, Glycaemic Index (GI) and Glycaemic Load (GL) of Gros michel, Red Dacca, lady's finger and green mutant

Varieties	Portion consumed (g)	Available carbohydrate (g/100 g)	Glycaemic index (%)	Glycaemic load (%)
Gros michel	404	6.19 ± 0.15^{c}	52	3.22
Red dacca	398	6.29 ± 0.02^{c}	24	1.52
Lady's finger	601	4.29 ± 0.18^{a}	45	1.91
Green mutant	444	5.63 ± 0.07^{b}	71	3.99

Mean±SD of triplicate determinations, Means with the different alphabet (a-c) as superscript differed significantly ($p<0.05$) while Means with the similar alphabet (a-c) as superscript are comparable ($p>0.05$)

Table 2: General Characteristics of the Subjects (n = 13)

Parameters	Mean	SD
Real age	23.46	3.36
Height	170.38	10.29
Weight	63.72	10.65
Visceral fat	3.54	0.97
Body fat	24.20	9.04
Muscle fat	33.92	7.15
Resting metab. Rate	1430.62	221.72
Biological age	26.08	8.84
BMI (kg m^{-2})	21.82	1.60

Mean±SD of triplicate determinations, n: Number of subjects

Table 3: Mean glucose readings (mg dL^{-1}) of Gros Michel, Red Dacca, lady's finger and green mutant and glucose drink

		Minutes			
Variety	FBS	30	60	90	120
Gros michel banana	88±6	118±12	107±12	104±16	94±11
Red dacca banana	95±8	113±12	102±9	104±8	98±10
Lady's finger banana	90±10	115±20	106±19	98±13	96±9
Green mutant banana	88±8	111±15	102±13	102±10	101±11
Glucose drink	89±2	148±7	124±5	112±3	98±6

Mean±SD of triplicate determinations, FBS: Fasting blood sugar

Table 4: Sensory evaluation of gros Michel, Red Dacca, lady's finger and green mutant

Varieties	Colour	Flavor	Taste	Texture/Mouth feel	General acceptance
Gros michel	6.77 ± 1.87^{b}	7.23 ± 1.63^{b}	7.63 ± 1.47^{b}	7.40 ± 1.57^{b}	7.43 ± 1.57^{b}
Red dacca	8.27 ± 0.69^{c}	7.57 ± 1.33^{b}	7.60 ± 1.30^{b}	7.63 ± 1.38^{b}	7.77 ± 1.43^{b}
Lady's finger	4.43 ± 1.94^{a}	5.20 ± 1.97^{a}	5.63 ± 2.16^{a}	5.53 ± 2.05^{a}	5.03 ± 2.24^{a}
Green mutant	7.07 ± 1.80^{b}	6.53 ± 1.66^{b}	6.47 ± 1.87^{ab}	6.77 ± 1.74^{b}	6.70 ± 1.73^{b}

Mean±SD of sensory score (n = 30), Means with different alphabet (a-c) as superscript differed significantly ($p<0.05$) while Means with similar alphabet (a-c) as superscript are comparable ($p>0.05$)

postprandial) while subjects that consumed Gross Michel variety had the least (94 mg dL^{-1}).

The sensory attributes of the banana varieties are presented in Table 4. Scores for color ranged from 4.43 in Lady's Finger to 8.27 in Red Dacca, flavor 5.20 in Lady's Finger to 7.57 in Red Dacca, taste 5.63 in Lady's Finger to 7.63 in Gros Michel, Texture/ Mouth Feel 5.53 in Lady's Finger to 7.63 in Red Dacca and General Acceptance 5.03 in Lady's Finger to 7.77 in Red Dacca. Also, the sensory attributes of Gros Michel, Red Dacca and Green Mutant were similar ($p>0.05$) but significantly different ($p<0.05$) from Lady's finger.

DISCUSSION

The mean age (23.46±3.36) of the subjects shows that they were young adults. The result was higher than reported elsewhere[30] which indicated a mean age of 12.6±3.6 years and lower than that in another study[31] where a mean age of 31.2±4.8 years was used to investigate the glycaemic index, glycaemic load and the glycaemic response of 17 varieties of dates grown in Saudi Arabia. The mean BMI (21.82 kg m^{-2}) shows that the subjects were healthy and had normal BMI range[30]. The subjects were neither overweight nor underweight although the research had its focus on diabetes management which affects people of different age groups especially the elderly [32]. The study by AlGeffari *et al.*[31] reported a BMI of 27.5 kg m^{-2} which indicated recruitment of overweight subjects. The disparity in result could be as result of the objectives and target group needed for the study.

The available carbohydrate content of food represents the carbohydrates that can be broken down and absorbed by the human intestine when consumed[24]. The highest amount of available carbohydrate was found in Red Dacca (6.29 g/100 g). This shows that it contains starch and soluble sugars in a higher amount than the other varieties of banana studied.

The glycaemic index of banana varieties studied shows that Green Mutant has a high glycaemic index (71%) while Gros Michel (52%), Red Dacca (24%) and Lady's Finger (45%) had a low glycaemic index. Glycaemic response refers to the change in blood glucose level after consumption of a carbohydrate food[6,27]. Glycaemic index of foods is affected by a variety of factors such as variety, carbohydrate type and fibre[33]. Different studies conducted on glycaemic response of banana varieties show that varieties have different GI values[20]. This is consistent with the results of Deepa *et al.*[33] where variety affected the glycaemic index of rice varieties. Some studies have reported higher GI and GL levels on banana varieties which is not in line with established GI and GL range for banana[6,27] which could be as a result of the variety used or the method of calculation used to derive such higher values[18,19]. The result from the present study shows that Green Mutant will not be very appropriate for diabetic subjects and it could cause a glycaemic spike for diabetic patients. Thus, it should not be recommended as a healthy snack for diabetic patients under dietary management or pharmacological drugs to regulate blood glucose levels. The glycaemic index of Red Dacca and Lady's Finger species of banana was low (<55), hence the assertion among retailers and indigenous people that they are medicinal could be true.

Glycaemic load is essential in the determination of the glycaemic effects of food[34] and this is used in adjusting portion sizes to an adequate amount[35]. Banana is a fruit that has a low glycaemic load. Low glycaemic load foods have been associated with lowering the risk of developing type-2 diabetes and coronary heart disease[36,37] and may also help individuals with insulin resistance[31]. Glycaemic load measures the degree of insulin demand and glycaemic response followed by a particular amount of food. This reflects both quality and quantity of dietary carbohydrate[38]. WHO/FAO recommends the consumption of low glycaemic index and glycaemic load food to prevent lifestyle-related non-communicable diseases[24].

The study on the glycaemic response of Green Mutant had a lower glycaemic response than Gros Michel, Red Dacca and Lady's Finger. The lower the glycaemic load, the smaller the expected increase in blood glucose (Glycaemic response)[25]. Green Mutant from the study had a low glycaemic load of 3.99 but it was higher than the GL of Gros Michel, Red Dacca and Lady's Finger which were 3.22, 1.52 and 1.91, respectively. This could be explained by the amount of available carbohydrate (carbohydrate that is digested and absorbed into the blood and metabolized) and/or fiber content of the banana varieties which affects the rate of gastric emptying and small intestine absorption or other factors[16].

The Sensory attributes of the banana varieties show that Lady's Finger was the least accepted (5.03). This may be because it has a sub-acid, apple-like taste [39]. Red Dacca scored the highest for sensory acceptability (7.77). This might be due to the carbohydrate content of the variety. However, Red Dacca is one banana that most people see as the banana for the poor, but it has shown that they have the best glycaemic effect.

CONCLUSION

The study determined the glycaemic response and sensory attributes of banana varieties commonly consumed in Enugu State. Glycaemic response study was done to ascertain the effect of the banana varieties on the postprandial blood glucose level. Sensory attributes were determined to check the relationship between taste and carbohydrate content of the banana varieties.

Red Dacca contained the lowest value for glycaemic index and glycaemic load which makes it a healthy fruit for diabetics. A relationship exists between taste and carbohydrate content of foods. This could be seen in the results on the sensory acceptability of Red Dacca in relation to its carbohydrate content. The sensory acceptability of Red Dacca was directly proportional to its carbohydrate content.

SIGNIFICANCE STATEMENT

The study shows that the assumptions and controversies surrounding the consumption of banana among diabetics are understood and discovered that all individuals can consume banana with more caution when it is green mutant variety. However, portion size control is paramount when eating any of the variety for every individual. This study provides information for evidence-based dietary counseling and nutrition education in the clinical or community setting, which can be used for further purposes in the future.

REFERENCES

1. FAO., 2010. FAOSTAT-PC. Rome.
2. UNCTAD, 2016. Banana. Geneva, Pages 21.
3. Frison, E.A., Escalant, J.V. and S. Sharrock, 2004. The global musa genomic consortium: a boost for Banana improvement. In: Banana Improvement: Cellular, Molecular, Biology and Induced Mutations, Jain, M.S. and R. Swennen, Science Publishers, Inc., Enfield, pp: 200-210.
4. Institute of Medicine, 2002. Dietary Reference Intakes for Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein and Amino Acids. National Academies Press, Washington, DC., pp: 7-69.
5. Macdonald, I.A., 1999. Dietary reference intakes for energy, carbohydrate, fiber, fat, fatty acids, cholesterol, protein, and amino acids. Eur. J. Clin. Nutr., 53: 101-106.
6. Marsh, K., A. Barclay, S. Colagiuri and J. Brand-Miller, 2011. Glycemic index and glycemic load of carbohydrates in the diabetes diet. Curr. Diab. Rep., 11: 120-127.
7. Sadler, M., 2011. Food, glycemic response and health. ILSI Europe Report Series. 1-30.
8. Wolever, T.M.S., L. Katzman-Relle, A.L. Jenkins, V. Vuksan, R.G. Josse and D.J.A. Jenkins, 1994. Glycemic index of 102 complex carbohydrate foods in patients with diabetes. Nutr. Res., 14: 651-669.
9. Liu, P., T. Perry and J.A. Monro, 2003. Glycaemic glucose equivalent: validation as a predictor of the relative glycaemic effect of foods. Eur. J. Clin. Nutr., 57: 1141-1149.
10. Wolever, T.M., D.J. Jenkins, A.L. Jenkins and R.G. Josse, 1991. The glycemic index: Methodology and clinical implications. Am. J. Clin. Nutr., 54: 846-854.
11. Dona, A.C., G. Pages, R.G. Gilbert and P.W. Kuchel, 2010. Digestion of starch: *In vivo* and *in vitro* kinetic models used to characterise oligosaccharide or glucose release. Carbohydrate Polymers, 80: 599-617.
12. Das, S.K., C.H. Gilhooly, J.K. Golden, A.G. Pittas and P.J.Fuss *et al*., 2007. Long-term effects of 2 energy-restricted diets differing in glycemic load on dietary adherence, body composition, and metabolism in CALERIE: a 1-y randomized controlled trial. Am. J. Clin. Nutr., 85: 1023-1030.

13. Atkinson, F.S., K. Foster-Powell and J.C. Brand-Miller, 2008. International tables of glycemic index and glycemic load values: 2008. Diabetes Care, 31: 2281-2283.
14. Riccardi, G., A.A. Rivellese and R. Giacco, 2008. Role of glycemic index and glycemic load in the healthy state, in prediabetes, and in diabetes. Am. J. Clin. Nutr., 87: 269S-274S.
15. Muhammad, M.U., R. Jiadong, N.S. Muhammad and B. Nawaz, 2019. Stratified diabetes mellitus prevalence for the northwestern nigerian states, a data mining approach. Int. J. Environ. Res. Public Heal., 10.3390/ijerph16214089
16. Eleazu, C.O., 2016. The concept of low glycemic index and glycemic load foods as panacea for type 2 diabetes mellitus; prospects, challenges and solutions. Afr. Health Sci., 16: 468-479.
17. Osama, A.J. and A.E. Shehab, 2015. Psychological wellbeing and biochemical modulation in response to weight loss in obese type 2 diabetes patients. Afr. Health Sci., 15: 503-511.
18. Adediran, O.S., I. Ogunlade, T.H. Raimi, A.K. Jimoh and M.A. Azeez *et al*., 2019. A study of blood glucose response following ingestion of ripe banana in healthy and diabetic Nigerian adults. J. Phytopharmacol., 8: 286-290.
19. Eagappa, K., M.M. Mathew and S. Sasikumar, 2015. Assessment of glycaemic index and glycaemic load in selected banana varieties. Int. J. Res. Health Sci., 3: 89-93.
20. Hettiaratchi, U.P.K., S. Ekanayake and J. Welihinda, 2011. Chemical compositions and glycemic responses to banana varieties. Int. J. Food Sci. Nutr., 62: 307-309.
21. Nowotny, A., 2011. Carbohydrate determination by Phenol-Sulfuric acid. In: Basic Exercises in Immunochemistry, Nowotny, A., Springer, Berlin. Heidelberg, pp: 171-173.
22. WHO, 2007. Multi centre growth reference study group. WHO child growth standard: method and development; length/height for age, weight for age, weight for length and body mass index. World Health Organization, Geneva. Pages: 312.
23. Fahey, J.W., 2005. *Moringa oleifera*: A review of the medical evidence for its nutritional, therapeutic and prophylactic properties. Part 1. Trees Life J., Vol. 1. 10.1201/9781420039078.ch12
24. FAO/WHO., 1998. Carbohydrate in human nutrition. Rome. ISBN: 92-5-104114-8.
25. Foster-Powell, K., S.H.A. Holt and J.C. Brand-Miller, 2002. International table of glycemic index and glycemic load values. Am. J. Clin. Nutr., 76: 5-56.
26. Hanhineva, K., R. Torronen, I. Bondia-Pons, J. Pekkinen, M. Kolehmainen, H. Mykkanen and H. Poutanen, 2010. Impact of dietary polyphenols on carbohydrate metabolism. Int. J. Mol. Sci., 11: 1365-1402.
27. Brand-Miller, J., S.H. Holt, D.B. Pawlak and J. McMillan, 2002. Glycemic index and obesity. Am. J. Clin. Nutr., 76: 2815-2855.
28. Lim, J., 2011. Hedonic scaling: A review of methods and theory. Food Qual. Preference, 22: 733-747.
29. Adubofuor, J., I. Amoah, V. Batsa,, P.B. Agyekum and J.A. Buah, 2016. Nutrient composition and sensory evaluation of ripe banana slices and bread prepared from ripe banana and wheat composite flours. Am. J. Food Nutr., 4: 103-111.
30. Queiroz, K.C., I.N. Silva and G. Alfenas, 2012. Influence of the glycemic index and glycemic load of the diet in the glycemic control of diabetic children and teenagers. Nutr. Hosp., 27: 1-10.
31. AlGeffari, M.A., E.S. Almogbel, T.A. Homaidan, R. El-Mergawi and I.A. Barrimaha, 2016. Glycemic indices, glycemic load and glycemic response for seventeen varieties of dates grown in Saudi Arabia. Ann. Saudi Med., 36: 397-403.
32. IDF., 2019. IDF Diabetes Atlas. 9th Edn.
33. Deepa, G., V. Singh and K.A. Naidu, 2010. A comparative study on starch digestibility, glycemic index and resistant starch of pigmented ('Njavara' and 'Jyothi') and a non-pigmented ('IR 64') rice varieties. J. Food Sci. Technol., 47: 644-649.
34. Salmeron, J., A. Ascherio, E.B. Rimm, G.A. Colditz and D. Spiegelman *et al*., 1997. Dietary Fiber, glycemic load, and risk of NIDDM in men. Diabetes Care, 20: 545-550.
35. Amadi, J.A., 2017. Glycaemic index of three cocoyam varieties consumed in Imo state, Nigeria. J. Dietitians Assoc. Niger., 8: 96-103.
36. Livesey, G., R. Taylor, H. Livesey and S. Liu, 2013. Is there a dose-response relation of dietary glycemic load to risk of type 2 diabetes? Meta-analysis of prospective cohort studies. Am. J. Clin. Nutr., 97: 584-596.
37. Mirrahimi, A., R.J. De Souza, L. Chiavaroli, J.L. Sievenpiper and J. Beyene *et al*., 2012. Associations of glycemic index and load with coronary heart disease events: a systematic review and meta-analysis of prospective cohorts. J. Am. Heart Assoc., 10.1161/JAHA.112.000752
38. Augustin, L.S., C.W. Kendall, D.J. Jenkins, W.C. Willett and A. Astrup *et al*., 2015. Glycemic index, glycemic load and glycemic response: An International Scientific Consensus Summit from the International Carbohydrate Quality Consortium (ICQC). Nutr. Metab. Cardiovasc. Dis., 25: 795-815.
39. Ploetz, R.C., A.K. Kepler, J. Daniells and S.C. Nelson, 2007. Banana and Plantain: An Overview with Emphasis on Pacific Island Cultivars. Permanent Agriculture Resources, Hawaii, USA., pp: 27.