



ORIGINAL RESEARCH ARTICLE

STUDIES ON STARCH CHARACTERISTICS OF FLOUR PRODUCED FROM SIX VARIETIES OF MUSA SPP. FRUITS GROWN IN SOUTHWESTERN NIGERIA
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ABSTRACT

This research work investigated starch characteristics of flour produced from six varieties of Musa spp. fruits with the view of promoting its usage as base composition in food development and innovation. There is dearth of information on prediction of glyceamic response of different varieties of Musa spp. flour in literatures. This research work therefore investigated glyceamic responses of six Musa spp. flour using standard procedures. The descriptive and inferential statistical analysis of measured data was done using Turkey's post test procedures of GraphPad Prism version 4.00 for Windows. The results showed that the carbohydrate, total starch, slowly digested starch (SDS) and resistant starch (RS) composition of the samples ranged from 90.32 to 93.93%; 473.97 to 488.30 mg/g; 33.02 to 36.38% and 21.16 to 27.54, respectively. Furthermore, amylose, amylopectin and predicted glyceamic index (pGI) were ranged from 25.10 to 29.02%; 70.93 to 74.90% and 51.11 to 53.31%, respectively. Thus, the results of this study showed that Musa spp. varieties affected glyceamic responses of the flour. Therefore, it is concluded that all the six varieties of Musa spp. have low glyceamic index and appreciable levels of resistant starch. The data obtained will bridge the information gap for formulation and development of functional foods using Musa spp. flour as a baseline composition.

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1.0 Introduction

Nowadays, demands for foods rich in antioxidants and low glyceamic index (GI) beyond traditional nutrients are increasing worldwide. This is because it reduces the loss of lives related to risks from high blood pressure and abnormal blood sugars, cardiovascular challenges, diabetes and elevated cholesterol, (Hermansen *et al.*, 2006; Louie *et al.*, 2015). GI and glyceamic load (GL) are measure of glyceamic response frequently used as guide in foods selection or in innovated food products development (Hermansen *et al.*, 2006). The GIs of food materials can be easily evaluated either by *vivo* or *in vitro* techniques with high degree of accuracy (Argyri *et al.*, 2016). In many tropical countries, banana and plantain (*Musa* spp.) play a crucial role in the diet and food security of large number of population since larger percentage of the fruits cultivated in the region are transacted and consumed in the immediate environments (Daniells *et al.*, 2001). The fruits are largely consumed as deserts and staple foods by millions in the tropical sub-region. It is very rich in carbohydrate and vitamins in proportion that favourably compete with other notable staple foods such as sweet potato, cassava and potato (Adeniji and Tenkouano, 2008). In addition, it has high mineral contents such as Fe, Ca and K in a proportion that can meet daily dietary recommendations (Yarkwan and Uvir, 2015). Banana and plantain are perennial crops with over 80 cultivars grow rapidly and fruit all year round in the tropics and sub-tropics. The world annual output of banana is 106 million tons (MT) t while plantain recorded 13 MT with Africa playing a major role (FAO 2005). In Nigeria, plantain and their products are in high demand, and this is reflected by the relatively high price of the farm produce whereas banana market price is relatively low. Plantain and banana

products are consumed in different forms – chips, *dodo ikire* and elastic pastry popularly referred to as *amala* in Nigeria and *fufu* in Cameroon and other West African countries and prepare by mixing flour in boiling water into a stiff dough and eat with various sauces. This study then focuses on determination of starch characteristics of *Musa* spp. flour so as to serve as nutritional guideline for food product formulation and development from the fruits.

2. Materials and Methods

2.1 Source of materials

Six varieties of *Musa* spp. fruits (Plate 1) harvested at physiological matured stage were obtained from the Teaching and Research Farm, Obafemi Awolowo University (OAU), Ile-Ife, Osun State, Nigeria.



Plate 1: Six selected varieties of *Musa* spp. fruits considered for the experiment: (a) plantain (*agbagba*) (b) robusta (*omini ibile*) (c) red banana (*omini oyinbo*) (d) Lacatan (*saro*) (e) gold finger (*aponmode*) (f) bluggoe (*panbolabola*)

2.2 Sample preparation

Musa spp. fruits were processed into flour following the procedure of Adebayo *et al.* (2021) outlined in Figure 1.

Preparation of reagents: The following reagents were prepared following standard procedures and all the chemicals used in this study were analytical grades:

(a) HCl-KCl buffer (pH 1.5): 50 ml of 0.1M KCl was added to 41.4ml of 0.1M HCl and then transferred into a 100 ml standard flask and then made up to the mark with distilled water.

(b) Pepsin reagent: Pepsin (1.000 g) was dissolved in 5ml of HCl-KCl buffer and poured into 10ml standard flask. The solution was then made up to the mark with the buffer. The pepsin reagent (0.2 ml) is equivalent to 20 mg of pepsin.

(c) Tris-maleate buffer (pH 6.9): 50 ml of 0.1M HCl was added to 0.1M tris-maleate solution, it was then put into a 100 ml flask and dilute with distilled water up to the mark of the flask.

(d) α - amylase reagent (pH 6.9): α - amylase (10.4 mg) was weighed into a beaker, dissolved with tris-maleate buffer, poured into a 200 ml flask and made up to the mark with the buffer.

(e) Amyloglucosidase: Amyloglucosidase (50 mg) was measured into a beaker and dissolved with 5 ml of tris-maleate buffer, poured into a 10 ml flask and made up to 10ml with the buffer.

(f) Preparation of phosphate buffer (pH 6.9): Phosphate buffer was prepared by mixing 5.63 mL of 0.2 M solution of NaH_2PO_4 and 6.9 mL of 0.2 M of Na_2HPO_4 in a 25 mL flask and made up to mark with distilled water.

(g) Dinitrosalicylic acid (DNSA) reagent: The DNSA reagent was prepared by weighing 0.25 g of 3, 5 – dinitrosalicylic acid, 7.48 g of sodium potassium tatarate and 0.40 g of sodium hydroxide into a 25 mL standard flask, the content was dissolved with phosphate buffer (pH 6.9) and the solution was made up to mark with the buffer.

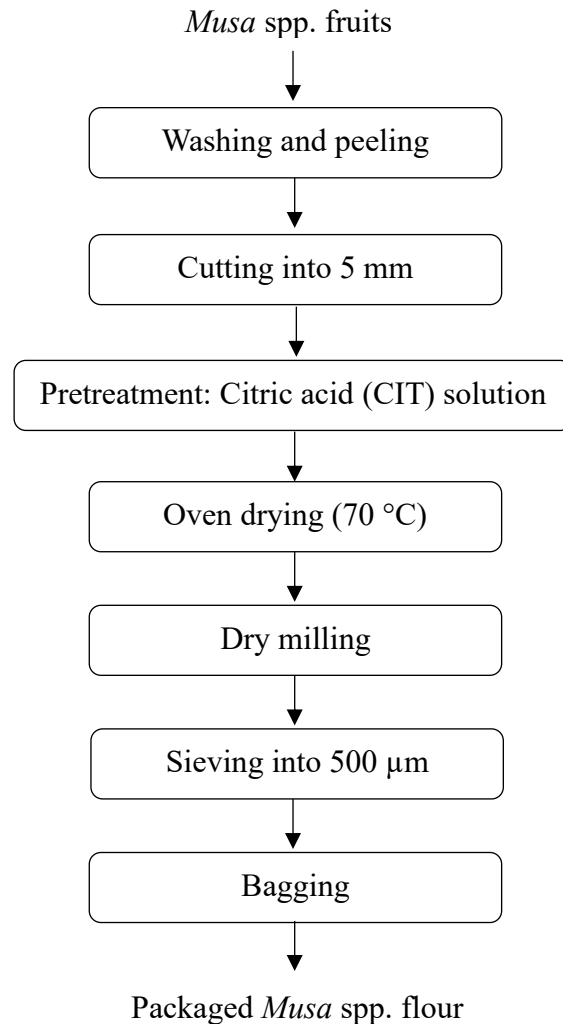


Figure 1: A flowchart for *Musa* spp. flour production (Adebayo et al., 2021)

2.3 Methods

Proximate analysis: Proximate composition of *Musa* spp. flour samples was determined according to AOAC (2005) methods.

Determination of total starch: The sample total starch was determined using the procedure documented by Falade et al. (2005).

Determination of reducing sugar using DNSA: The hydrolysate (1.0 mL) in a test tube was added to 0.1 mL of 0.1 M NaOH and 0.1 mL of DNSA reagent. The mixture was placed on a water bath for 15 min at 100 °C for development of orange colour in the test tube. The content was poured into a 25 mL flask and made up to mark with distilled water. The absorbance was measured at 590 nm using UV-spectrophotometer (UV 1601-Spectrophotometer, Shimadzu Corporation, Kyoto, Japan). The glucose release was extrapolated from the glucose standard curve. The glucose content value obtained was then converted to starch with a multiplication factor of 0.9.

In-vitro starch digestion rate: Determination of the flour *in-vitro* starch digestion was carried out using a procedure reported by Falade et al. (2005). The starch digestion rate was evaluated as the total starch

hydrolyzed expressed in percentage at different time. The digestibility curve obtained for each flour sample was fitted into the first-order kinetic equation (1) as documented by Falade *et al.* (2005).

$$C_{\alpha} = C_0 (1 - e^{-kt}) \quad 1$$

Where: C_{α} = Concentration at equilibrium, t; C_0 = Concentration at time 0; k = Pseudo-first order rate constant.

To obtain k, natural log of equation (1) was taken as presented in equation (2):

$$\ln(C_{\alpha} - C_0) = -\ln C_0 + \quad 2$$

First order hydrolysis curve of total starch (%) hydrolyzed against time and the area under the hydrolysis curve (AUC, 0 – 180 min) was calculated by integrating equation (1) to obtain equation (3) and simplified to equation (4) by applying the curve boundary conditions ($t_0 = 0 \text{ min.}$; $t_{\alpha} = 180 \text{ min.}$)

$$A = C_0(t_{180} - t_0) + \frac{C_0}{k}(e^{-kt_{180}} - e^{-kt_0}) \quad 3$$

$$A = 180 \times C_0 + \frac{C_0}{k}(e^{-180k} - 1) \quad 4$$

Hydrolysis index (HI) was calculated as the relationship between the (A) for a test food and (A) for a reference food (white bread), expressed as a percentage (Jeevetha *et al.*, 2014). From the result of HI, predicted glycemic index (pGI) was calculated using equation (5):

$$pGI = 39.71 + (0.549 \times HI) \quad 5$$

Where: pGI = predicted glycemic index; HI = hydrolysis index.

Rapidly digestible starch, slowly digestible starch and resistant starch (RS) determination: The method of Hans *et al.* (2007) was used to estimate the rapidly digestible starch (RDS), slowly digestible starch (SDS) and resistant starch (RS). The RDS is the fraction of starch hydrolyzed within 30 min of incubation; SDS is the fraction hydrolyzed between 30 to 180 min and the fraction that remained unhydrolyzed after 180 min is regarded as the RS.

Determination of amylose/amylopectin: Evaluation of amylose content of the flour sample was done using method documented by Juan *et al.* (2006). Amylopectin content of the sample flour was then determined using equation (6) (Juan *et al.*, 2006).

$$Amylopectin, \% = 100 - amylose (\%) \quad 6$$

Statistical analysis: Descriptive and inferential statistical analysis of the data was carried out using Turkey's post test procedures of GraphPad Prism version 7.00 for Windows.

3. Results and Discussion

The proximate composition of six varieties of *Musa* spp. flour were presented in Table 1. The results showed that carbohydrate content ranged from 90.32 to 93.93% with plantain and goldfinger samples having lowest and highest values, respectively with no significant difference ($p < 0.05$) with the exception of plantain and robusta sample flours. Thus, all the varieties investigated are good sources of energy food with the implication that high starch content food products can be obtained from all the six *Musa* spp. varieties. The carbohydrate contents of the six varieties were significantly higher compared with staple foods such as yam (78.21%), potato (77.68%), rice (80.22%) and cassava (83.2%) as reported by Kirk and Sawyer, 1991 and USDA, 2009 in their separate studies. The results compared favourably with published data on carbohydrate contents of different varieties of *Musa* spp. flour which ranged from 72 to 90% (Ojure and Quadri, 2015; Ogundare- Akanmu *et al.*, 2015 and Yarkwan and Uvir, 2015). The crude fat content ranged from 1.67 to 5.08% with robusta and plantain having lowest and highest values, respectively. The values compared favourably with 0.85-1.65, 1.11 – 1.35 and 1.20 – 1.55% reported by Adeniji *et al.* (2007); Ojure and Quadri (2015); Yarkwan and Uvir (2015), respectively but higher than 0.2 – 0.95, 0.64 – 1.22 and 0.25 – 0.60% reported by Daramola and Osanyinlusi (2006); Ogundare-Akanmu *et al.* (2015) and Kiin-Kabari and Njoku (2016), respectively. The difference in the crude fat content of various varieties of *Musa* spp. is mainly due to variety. The low crude fat content of the flours enhances its storage life due to lowered chance of rancid flavor development (Yarkwan and Uvir, 2015). In comparison with other staple food flours, the crude fat content of *Musa* spp. flours are higher than that of cassava (0.5%) (Adebowale *et al.*, 2008). The crude protein content ranged from 1.52 to 1.98% with samples red banana and plantain flour samples having minimum and maximum values, respectively.

Table 1: Proximate composition of six varieties of Nigerian grown *Musa* spp. flours

Varieties	Moisture (%)	Crude fat d.b (%)	Crude fibre (%)	Ash (%)	Crude protein (%)	Carbohydrate (%)
PS	11.01 ^a ±0.04	5.08 ^a ±0.68	1.00 ^a ±0.05	1.64 ^a ±0.02	1.96 ^a ±0.06	90.32 ^c ±0.61
BS	10.82 ^a ±0.13	2.88 ^b ±0.33	0.27 ^e ±0.01	1.41 ^b ±0.30	1.70 ^b ±0.03	93.74 ^a ±0.64
RBS	10.89 ^a ±0.09	2.85 ^b ±0.42	0.49 ^d ±0.03	1.41 ^b ±0.11	1.52 ^c ±0.13	93.75 ^a ±0.48
SS	10.97 ^a ±0.15	2.90 ^b ±0.05	0.78 ^b ±0.00	1.32 ^b ±0.03	1.69 ^b ±0.10	93.40 ^a ±0.42
AS	11.08 ^a ±0.28	1.75 ^c ±0.22	0.66 ^c ±0.03	1.68 ^a ±0.13	1.98 ^a ±0.18	93.93 ^a ±0.36
IBS	11.05 ^a ±0.38	1.67 ^c ±0.10	0.68 ^c ±0.00	1.71 ^a ±0.01	1.99 ^a ±0.01	92.39 ^b ±0.04

Values are mean ± standard deviation of triplicate analysis; values followed by the same letter in the same column are not significantly different ($p < 0.05$). PS = plantain flour; BS = bluggoe/plantain banana flour; RBS = red banana flour; SS = Lacatan/Saro flour; AS = Gold finger flour; IBS = Robusta/ *Omini ibile* flour

The crude protein content of the flour samples investigated are significantly different ($p < 0.05$) with the exception of plantain, goldfinger and robusta flour samples. This implies that variety plays a crucial role in the crude protein content of *Musa* spp. flour. The crude protein values favourably compared with 1.05 – 2.25% documented by Daramola and Osanyinlusi (2006) but lower than the 3.69 – 5.46; 3.6 – 3.86 and 3.6% as reported by Adeniji *et al.* (2007); and Yarkwan and Uvir (2015), respectively. With respect to other staple food flours, the crude protein contents of the flours were higher compared to cassava flour protein content (1.14%) (Adebowale *et al.*, 2008). Although the protein contents of *Musa* spp. flours are low, its nutritive quality is the energy value it can supply to its consumers (Adebowale *et al.*, 2008). The ash content values ranged from 1.32 to 1.71% with bluggoe and plantain flour samples having lowest and highest values, respectively. The values are significantly different ($p < 0.05$). The ash content provides an estimate of the mineral element present in the samples. It is also referred as an inorganic content residue remaining after the organic matter has been burnt away. The values compared favourably with 0.55 – 3.60 and 1.5 – 1.65% reported by Daramola and Osanyinlusi (2006) and Kiin-Kabari and Njoku (2016), respectively. However, in comparison with other staple flours, its value is higher than that of 0.8% of cassava flour (Adebowale *et al.*, 2008). The crude fibre content ranged from 0.27 to 1.00% with bluggoe and plantain flour samples having the lowest and highest values, respectively. There is significant difference ($p < 0.05$) in the crude fibre contents of the samples with the exception of goldfinger and robusta flour samples. The crude fibre has been extensively used to measure cellulose, hemicellulose and lignin of food samples. The crude fibre contents of *Musa* spp flours compared favourably with that of rice (0.9%) but lower than that of maize (4.47%) (Adebowale *et al.*, 2008). It may be inferred that *Musa* spp. flours at first stage of maturity are very rich in carbohydrate irrespective of variety but low in crude protein and fat contents with the exception of plantain flour sample which its crude protein content was 5.08%.

The total starch (TS) of the flours ranged from 488.30 to 473.97 mg/g with lacatan and bluggoe flour samples having the lowest and highest values, respectively (Table 2). There is a significant difference ($p < 0.05$) in the total starch fractions of the six varieties. This implies that total starch fraction of *Musa* spp. flours at first stage of maturity is affected by variety. The values obtained compared favourably with the total starch fractions of other staple food flours such as cassava, potato, rice and yam flours. Starch is mainly divided into three categories using nutritional classification as a basis: rapidly digestible starch (RDS), slowly digestible starch (SDS) and resistant starch (RS) (Hans *et al.*, 2006). Rapidly digestible starch (RDS) and slowly digestible starch (SDS) were calculated from the *in vitro* starch digestion at 30 and 120 min. of enzymatic incubation. The RDS values for all the varieties investigated ranged from 26.52 (lacatan flour sample) to 30.12% (plantain flour sample) (Table 2). There is significant difference ($p < 0.05$) among all the varieties investigated. RDS is widely used as an alternative method for starch digestion evaluation - when the RDS fraction is high, the starch is considered rapidly digested resulting into a high glycemic response *in vivo* (Falade *et al.*, 2005). Also, the slowly digested starch (SDS) values for all the varieties investigated ranged from 33.02 (red banana flour) to 36.38% (gold finger flour) (Table 2). There is a significant difference ($p < 0.05$) of all the varieties investigated. The RSD and SDS values of all the *Musa* spp. varieties investigated showed that fewer fractions of the starch were digested at first 30 min. of enzymatic hydrolysis as compared with thereafter, implying that the sample starch was slowly hydrolyzed within the first 30 min. The resistant starch (RS) values for all the varieties investigated

ranged from 21.16 (gold finger flour) to 27.54% (bluggoe flour). The resistant starch (RS) values were significantly different ($p < 0.05$) for all the varieties investigated. The relatively high RS values of all the *Musa* spp. flours may be due to crystalline structure of food matrix that reduces susceptibility to enzymatic digestion.

Table 2: Starch fractions of six varieties of Nigeria grown *Musa* spp. flour

Sample	TS (mg/g)	RDS (%)	SDS (%)	RS (%)
PS	485.63 ^a ±2.08	30.12 ^b ±0.010	33.99 ^e ±0.001	24.58 ^g ±0.001
BS	488.30 ^a ±2.81	27.50 ^f ±0.006	33.36 ^f ±0.003	27.54 ^f ±0.001
RBS	485.63 ^{ab} ±1.53	27.52 ^e ±0.005	33.02 ^g ±0.002	23.92 ^e ±0.001
SS	473.97 ^c ±0.53	26.72 ^g ±0.003	35.43 ^d ±0.005	23.51 ^d ±0.001
AS	479.63 ^b ±2.09	30.02 ^c ±0.009	36.38 ^b ±0.008	21.16 ^c ±0.003
IBS	484.63 ^{ab} ±1.15	28.88 ^d ±0.005	36.34 ^c ±0.007	22.74 ^b ±0.006
WWF	483.30 ^{ab} ±0.001	54.52 ^a ±0.014	28.04 ^a ±0.017	13.45 ^a ±0.018

Values are mean ± standard deviation of triplicate analysis; Values followed by the same letter in the same column are not significantly different ($p < 0.05$); PS = plantain flour; BS = bluggoe/plantain banana flour; RBS = red banana flour; SS = Lacatan/Saro flour; AS = Gold finger flour; IBS = Robusta/ *Omini ibile* flour; WWF = white wheat flour; RDS- rapidly digested starch; SDS – Slowly digested starch and RS – Rapidly digested starch TS – Total starch

The amylose values ranged from 25.10 to 29.02% with sample gold finger and bluggoe flour samples having lowest and highest values, respectively (Table 3). There is significant difference ($p < 0.05$) in the amylose values of all the varieties investigated. Based on the accepted classification of amylose (Juan *et al.*, 2006; Jeevetha *et al.*, 2014), the amylose contents of *Musa* spp. flours are classified as high. The amylose content values of the six varieties of *Musa* spp flours compared favourably with 26% of white rice (Musa *et al.*, 2011) but lower than 35.77 – 40.68% reported by Adejumo *et al.* (2013) for different varieties of maize flours. Juan *et al.* (2006) reported that high amylose fraction (>25%) food had demonstrated resulting into a lower blood glucose and insulin response, vice versa (Argyri *et al.*, 2016).

Table 3: Amylose-amylopectin composition of six varieties of Nigeria grown *Musa* spp. flour

Varieties	Amylose (%)	Amylopectin (%)	Amylose : amylopectin
PS	27.85 ^c ±0.12	72.15 ^b ±0.18	0.386 ^c ±0.003
BS	29.02 ^c ±0.18	70.98 ^a ±0.17	0.409 ^d ±0.004
RBS	26.32 ^b ±0.03	73.68 ^c ±0.03	0.357 ^b ±0.001
SS	26.15 ^c ±0.04	73.85 ^b ±0.04	0.354 ^c ±0.001
AS	25.10 ^a ±0.07	74.90 ^d ±0.07	0.335 ^a ±0.001
IBS	26.69 ^c ±0.15	73.31 ^b ±0.15	0.364 ^c ±0.003

Values are mean ± standard deviation of triplicate analysis; Values followed by the same letter in the same column are not significantly different ($p < 0.05$); PS = plantain flour; BS = bluggoe/plantain banana flour; RBS = red banana flour; SS = Lacatan/Saro flour; AS = Gold finger flour; IBS = Robusta/ *Omini ibile* flour

The amylopectin content ranged from 70.98 (bluggoe flour) to 74.90% (gold finger flour). Significant difference ($p < 0.05$) was observed among the amylopectin contents of the flours. The amylose-amylopectin ratio ranged from 0.34 – 0.41 with samples gold finger and bluggoe flour samples having minimum and maximum values, respectively. The amylose/amylopectin ratio has been widely used as an important implication on food quality, industrial application and health (Jeevetha *et al.*, 2014; Argyri *et al.*, 2016). Ravi and Musataffa (2013) reported that the unripe plantain beneficial advantage is associated with its carbohydrate characteristics and resistant starch. The kinetic (digestibility) constant of the *Musa* spp. flours ranged from 0.0033 to 0.0040 min⁻¹ with bluggoe and gold finger flour samples having the lowest and highest values, respectively with no distinct difference in their kinetic (digestibility) constants (Table 4). In comparison with kinetic constant (0.070 min⁻¹) of white wheat flour, it showed that digestibility of *Musa* spp. flours is 20 times slower.

Hydrolysis index (HI) of the six varieties of *Musa* spp. flours ranged from 20.77 to 24.78% with bluggoe and gold finger flour samples having the minimum and maximum values, respectively. The hydrolysis indices of the six flours are low in comparison with the 100% standard for white wheat flour. The hydrolysis index measures the theoretically digestible starch proportion (under the conditions of the study) (Falade *et al.*, 2005). In comparison with the HI value documented by Jeevetha *et al.* (2014), the HI values of all varieties of *Musa* spp. investigated were highly correlated with RDS ($R^2 = 0.93$). Falade *et al.* (2005) also documented similar correlation between HI and RDS. This implies that the RDS could be used an alternative predictor for *Musa* spp. flour digestion.

Table 4: *In vitro* starch digestibility parameters of six varieties of Nigeria grown *Musa* spp. flours

Sample	k (min ⁻¹)	AUC	HI (%)	pGI
PS	0.0035	0.259	23.443	52.580
BS	0.0033	0.230	20.765	51.110
RBS	0.0039	0.263	23.752	52.750
SS	0.0038	0.267	24.131	52.958
AS	0.0040	0.274	24.776	53.312
IBS	0.0037	0.262	23.735	52.741
WWF	0.0700	9048	100.000	94.600

PS = plantain flour; BS = bluggoe/plantain banana flour; RBS = red banana flour; SS = Lacatan/Saro flour; AS = Gold finger flour; IBS = Robusta/ *Omini ibile* flour; WWF = White wheat flour; k = kinetic constant (min⁻¹); AUC = Area under curve; HI = Hydrolysis index; pGI = Predicted glycemic index

The predicted glycemic index (pGI) of the six varieties of *Musa* spp. flours investigated ranged from 51.11 to 53.31 with bluggoe and gold finger flour samples having the minimum and maximum values, respectively. The differences in pGI suggest varying amounts of amylose and amylopectin in the varieties. The values obtained compared favourably with 39.04 – 51.05 reported by Oko *et al.* (2015) for eight unripe plantain cultivars in Nigeria. The pGI measures the blood glucose-raising ability of the available carbohydrate in food samples (Wolever *et al.*, 2008). According to the official classification, high pGI foods (>70), intermediate pGI foods (55 – 70) and low pGI foods (<55) raise blood glucose level rapidly, moderately and slowly, respectively (Brand-Miller *et al.*, 2003). This indicates that flours of the *Musa* spp. varieties investigated are classified as low pGI staple foods. However, glucose metabolic disorders are often led to high pGI food consumption. Heather *et al.* (2001) and Brand-Miller *et al.* (2003) reported that low pGI foods improve metabolic mechanisms in adult patients with type 2 diabetes mellitus and blood glucose levels. Furthermore, the health benefits of low pGI diets have been associated with increased insulin sensitivity, reduce food intake and body weight, and may reduce serum cholesterol (Wolever *et al.*, 2008). The low pGI values obtained in this study may be attributed to the starch characteristics of the flours coupled with the high amylose content. Similar trend of high amylose and low pGI had been documented by other authors (Bahado-Singh *et al.*, 2006; Wolever *et al.*, 2008). High amylose content foods digests more slowly because amylose is a polymer of simple sugars with straight, unbranched chains which forms a not easily gelatinized solid bond whereas amylopectin is highly branched, available for enzymatic digestion with the open structure and therefore have hyperglycemic activity than food containing high amylose (Bahado-Singh *et al.*, 2006; Widowati *et al.*, 2010). Reduced risk of metabolic-degenerative disorders and blood glucose level (type 2 diabetic) have been associated with low pGI foods.

4. Conclusion

Starch characteristics of *Musa* spp. flour had been documented. The results showed that all the samples investigated have considerable resistant starch and low glycemic index with little or no difference in the glycemic index values among the varieties investigated. The study therefore provides nutritional guideline data for selection of low glycemic index flour in the development and formulation of new products.

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