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Chemical and functional properties of flour blends of unripe plantain, pigeon pea and moringa seed in the development of an antidiabetic food product

Oluwamukomi Mathew Olusola[1*], Oboh Ganiyu[2], Agbede Johnson Oluwasola[3], Oyeleye Idowu Sunday[4], Sodipo Mopelola .Ajoke[1]

[1]Dept. of Food Science & Tech., Federal University of Technology, Akure, Nigeria.
[2]Dept. of Biochemistry, Federal University of Technology, Akure, Nigeria
[3]Dept. of Animal Production and Health, Federal University of Technology, Akure, Nigeria.
[4]Dept. of Biomedical Technology, Federal University Technology, Akure, Nigeria

Abstract

Consumption of low glycaemic foods could contribute to the reduction of incidence and prevalence of heart disease, cardiovascular disease, diabetes and obesity. Hence, there is need to develop food formulation with properties to manage these diseases and without side effects. Studies have shown that unripe plantain, moringa seed and pigeon pea possessed these potentials. This study aimed to develop a flour blend from them with such potentials. They were processed into flour and then mixed in ratios to form six (6) functional blends. The blends were analysed to determine their proximate, mineral and functional properties. The results showed that the moisture, protein, fat, crude fibre, ash and carbohydrate contents of the blends ranged from 6.15 to 7.72%, 4.29 to 15.40%, 3.49 to 7.58%, 1.43 to 2.24%, 2.23 to 2.47% and 68.01 to 76.85% respectively. There was a significant improvement in their protein, minerals and functional properties and also a significant increase in the bulk density, swelling capacity and least gelation concentration with supplementation. These blends could be of good use in the development of food products requiring high gelling properties. Their Sodium/Potassium ratio of less than one shows that these blends will serve well in ameliorating problems associated with high blood pressure and hypertension. However, the low values of Ca/P ratio of less than one shows that any products to be developed from the blends has to be supplemented with calcium rich sources.

Key words: plantain, pigeon pea, moringa, functional blends, antidiabetic.

*Correspondence:
moluwamukomi@futa.edu.ng

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1.0 INTRODUCTION

Glycaemic properties of food are being a major interest of research, and their possible contribution to nutrition and health (Howlett and Ashwell, 2008). The glycaemic index measures the speed at which a food breaks down in the digestive system to form glucose. Also, it is the ranking of foods based on the postprandial blood glucose response compared with reference food (Foster-Powell and Brand-Miller, 1995). Low glycaemic foods are digested and metabolized slower than high glycaemic foods. According to World Health Organisation, low glycaemic food is recommended to help in preventing diabetes and gain better control over blood sugar balance. Consumption of low glycaemic foods could contribute to reduce incidence and prevalence of heart disease, cardiovascular disease, diabetes and obesity (Rizkalla *et al.*, 2002; Jenkins, 2007).

Plantain (*Musa AAB*) is a rhizomatous perennial crop eaten as a staple food by many people in Nigeria (Adeniji *et al*., 2006). Matured green plantain pulp is rich in iron, potassium, vitamin A and C but low in protein (Adegboyega, 2006). It was reported that unripe plantain contains high content of resistant starch and dietary fibre with slowly digestible total starch of low glycaemic index (Oboh and Erema, 2010; Okafor and Ugwu, 2013).

Unripe plantain can be fried, roasted, baked, steamed, and made into flour or chips (Nwokocha and Williams, 2009). Unripe plantain can be processed into flour and eaten as dough meal. Unripe plantain dough meal is usually consumed by diabetic patients in Nigeria to reduce postprandial glucose level (Ojewole and Adewunmi, 2003; Oboh and Erema, 2010; Agama-Acevedo *et al*., 2012).

The use of drug for the treatment of diabetes has been reported to have several side effect and diet therapy is gaining much attention in the management of diabetes (Adefegha *et al*., 2014). Hence, there is need for diabetic food formulation that could reduce blood glucose (hyperglycaemia) level with antioxidant property, and without 6side effects. Studies have shown that unripe plantain, moringa seed and pigeon pea possessed these potentials (Oboh *et al*., 2018; Gbenga- Fabusiwa *et al*., 2018). Therefore, this study seeks to develop functional blend from unripe plantain, moringa seed and pigeon pea that will be useful in the management of diabetes and be useful for other food purposes.

2.0 MATERIALS AND METHODS

Fresh unripe plantain and moringa seed were obtained from farm around Federal University of Technology, Akure while pigeon pea was purchased from Oba Market, Akure. Authentication of the samples was carried out in the Department of Crop, Soil and Pest Management (CSP), Federal University of Technology, Akure., Nigeria. All other reagents used were of analytical grade.

Fresh matured, unripe plantain pulp was processed into flour by using the method of Oluwalana *et al (*2011). The unripe plantain pulp was washed, peeled and sliced to about 2 mm diameter using knife. The sliced plantain pulp was blanched in a boiled water for 15 min and oven dried at 70oC for 24 h. It was then milled into flour using attrition mill and then sieve through 60 µm sieve. It was packaged into polyethylene bag and stored in a plastic under room temperature and stored for further use. Pigeon peas were processed into flour by the method described by Fasoyiro *et al*. (2010). The pigeon pea was cleaned, sorted and boiled for 20 min. Then, cooled, dehulled manually, washed and oven dried at 60^{o}C for 48 h. It was cooled, milled in the locally fabricated attrition mill and sieved with 60 µm sieve. It was then packaged into polyethylene bag and inside plastic stored under room temperature for further use. Moringa seed was processed to flour by using the method of Bichi *et al* (2012). The moringa seed was cleaned, sorted and dehulled manually. It was then oven dried at 60^{o}C for 24 h, cooled and milled by using Kenwood blender. It was sieved through 60 µm and packaged in polyethylene bag and plastic stored under room temperature for further use. The three samples were mixed together to form a functional blend as shown in Table 1.

Table 1 Formulation of flour blends from unripe plantain, pigeon pea and moringa seed flour (%)

Samples	Unripe plantain	Moringa seed	Pigeon pea
A	100	-	-
B	98	2	-
C	96	4	-
D	50	-	50
E	49	2	49
F	48	4	48

(Oboh *et al*., 2018) with little modification

Keys:

- A- 100 % plantain flour
- B- 98 % plantain flour + 2 % moringa seed flour
- C- 96 % plantain flour + 4 % moringa seed flour
- D- 50 % plantain flour + 50 % pigeon pea flour
- E- 49 % plantain flour + 49 % pigeon pea flour + 2 % moringa seed flour
- F- 48 % plantain flour + 48 % pigeon pea flour + 4 % moringa seed flour

2.1 Methods

2.2.1 Preparation of unripe plantain flour

Fresh matured, unripe plantain pulp was processed into flour by using the method of Oluwalana *et al* (2011). The unripe plantain pulp was washed, peeled and sliced to about 2 mm diameter using knife. The sliced plantain pulp was blanched in a boiled water for 15 min and oven dried at 70^{o}C for 24 h. It was then milled into flour using attrition mill and then sieve through 60 µm sieve. It was packaged into polyethylene bag and stored in a plastic under room temperature and stored for further use. The flow chart is shown in Fig 1.

Matured Unripe Plantain Pulp

↓

Washing

↓

Peeling

↓

Cutting

↓

Blanching (10 min at 100^{o}C)

↓

Drying (70^{o}C for 24 h)

↓

Milling

↓

Sieving (60 µm)

↓

Packaging

↓

Unripe Plantain Flour

Figure 1 Production of unripe plantain flour
Source: Oluwalana *et al* (2011) with little modification

2.2.2. Preparation of pigeon pea flour

Pigeon peas were processed into flour by the method described by Fasoyiro *et al*. (2010). The pigeon pea was cleaned, sorted and boiled for 20 min. Then, cooled, dehulled manually, washed and oven dried at 60^{o}C for 48 h. It was cooled, milled in the locally fabricated attrition mill and sieved with 60 µm sieve. It was then packaged into polyethylene bag and inside plastic stored under room temperature for further use.

2.2.3 Preparation of moringa seed flour

Moringa seed was processed to flour by using the method of Bichi *et al* (2012). The moringa seed was cleaned, sorted and dehulled manually. It was then oven dried at 60^{o}C for 24 h, cooled and milled by using Kenwood blender. It was sieved through 60 µm and packaged in polyethylene bag and plastic stored under room temperature for further use.

3.0 ANALYSES

3.1 Determination of proximate composition of flour blends of unripe plantain, pigeon pea and moringa seed

The proximate composition of composite flour was determined using AOAC (2012) methods. Carbohydrate was calculated by difference by subtracting the sum of percentages of moisture, ash, fat, crude fibre and protein from 100%

3.2 Determination of mineral composition of the flour blends of unripe plantain, pigeon pea and moringa seed

The mineral elements were determined by the method described by AOAC (2012). Calcium, potassium, copper, zinc, iron, lead and cadmium were determined by using Atomic Absorption Spectroscopy (AAS Model SP9). The phosphorus was determined by using Vanodo-molybdate method.

3.3 Determination of functional properties of flour blends of unripe plantain, pigeon pea and moringa seed

The bulk density was determined according to the method described by Asoegwu *et al* (2006). Water absorption capacity was determined by using the method described by Adebowale *et al* (2005). The oil absorption capacity (OAC) was determined by the method described by Adebowale *et al* (2005). The swelling capacity was determined by the method described by Shad *et al* (2011). The least gelation concentration was determined by the method described by Adebowale *et al* (2005). The dispersibility was determined by the method described by Sodipo and Fashakin (2011).

4.0 RESULSTS AND DISCUSSION

4.1 Proximate composition of flour blends of unripe plantain, pigeon pea and moringa seed

The proximate composition of flour blends produced from unripe plantain pulp, pigeon pea and moringa seed are presented in Table 2 . The moisture content ranged from 6.19 to 7.72 %. It was observed that all the samples generally had low moisture content. This could be good for keeping quality of a flour (Ezeama, 2007). This value agreed with Iwanegbe *et al* (2019) in unripe plantain, soybean and ginger flour blends. Also, the low moisture content could prevent growth of microorganism and delay biochemical reactions. Although, sample D (50 % unripe plantain + 50 % pigeon pea) had the highest value while sample A (100 % unripe plantain) had the lowest value of moisture content. The values obtained agreed with the safe permissible level for the flour of 10 % (FAO, 2004). The low moisture content obtained could be because of drying method and equipment used. The low moisture content obtained agreed with the report of Famakin *et al* (2016) and Oluwajuyitan and Ijarotimi (2019) in plantain-based functional dough meal and plantain- based dough meal enriched with tigernut and defatted soybean respectively.

The protein content ranged from 4.57 to 16.47 %. There were significant differences in all the samples at $P < 0.05$. It was observed that the sample D to F had higher protein content and may be due to addition of pigeon pea flour. The value obtained for 100 % plantain (PLA) agreed with the report of Abioye *et al* (2011) and Badejo *et al* (2017) in plantain flour. Protein is essential for growth and development of the body, needed for repair of worn-out tissues.

Table 2: Proximate composition (%) of flour blends from unripe plantain, pigeon pea and moringa seed (dry weight basis)

Samples	Moisture	Protein	Crude fat	Crude fibre	Total ash	Carbohydrate	Energy (kcal/g)
A	6.19±0.08[c]	4.57±0.15[f]	6.22±0.05[b]	1.53±0.05[e]	2.56±0.20[a]	85.12±0.24[a]	414.71±1.21[b]
B	7.66±0.02[a]	9.93±0.07[e]	6.26.±2.32[b]	1.81±0.02[d]	2.42±0.15[a]	79.58±0.31[b]	414.36±0.42[b]
C	7.59±0.15[a]	11.60±0.09[d]	8.20±1.02[a]	1.92±0.03[c]	2.67±0.15[a]	75.61±0.90[c]	422.66±5.84[a]
D	7.72±0.15[a]	15.43±0.11[c]	5.93±1.14[b]	2.26±0.04[b]	2.68±0.15[a]	73.70±1.38[d]	409.89±5.21[b]
E	6.52±0.15[b]	16.22±0.04[b]	5.39±1.47[b]	2.32±0.02[b]	2.42±0.25[a]	73.65±1.63[d]	407.99±7.02[b]
F	6.51±0.15[b]	16.47±0.06[a]	5.51±0.54[b]	2.40±0.04[a]	2.50±0.05[a]	73.12±0.64[d]	407.97±2.55[b]

Mean (±SD) with different superscript in the same column are significantly different at P < .05

Key:

A- 100 % plantain flour
B- 98 % plantain flour + 2 % moringa seed flour
C- 96 % plantain flour + 4 % moringa seed flour
D- 50 % plantain flour + 50 % pigeon pea flour
E- 49 % plantain flour + 49 % pigeon pea flour + 2 % moringa seed flour
F- 48 % plantain flour + 48 % pigeon pea flour + 4 % moringa seed flour

Table 3: Mineral composition of flour blends (mg/100g) from unripe plantain, pigeon pea and moringa seed

Sample	A	B	C	D	E	F	Standard
Sodium	1.93±0.02[c]	1.99±0.02[b]	2.98±0.03[a]	1.52±0.02[d]	1.42±0.02[e]	1.94±0.02[c]	
Potassium	6.23±0.03[e]	5.38±0.03[f]	6.43±0.03[d]	7.22±0.02[c]	7.59±0.03a	7.33±0.02[b]	
Phosphorus	15.35±0.04[f]	17.43±0.03[e]	18.94±0.03[d]	19.15±0.03[c]	19.22±0.04[b]	21.72±0.03[a]	
Calcium	2.86±0.02[d]	2.35±0.03[f]	2.47±0.03[e]	5.83±0.03[c]	6.04±0.03[b]	6.37±0.03[a]	
Iron	0.93±0.02[a]	0.53±0.03[d]	0.56±0.03[d]	0.84±0.03[b]	0.65±0.03[c]	0.66±0.03[c]	
Zinc	0.46±0.02[a]	0.24±0.03[d]	0.28±0.03[cd]	0.31±0.03[bc]	0.34±0.04[b]	0.50±0.03[a]	
Manganese	0.05±0.03[ab]	0.02±0.01[b]	0.04±0.01[ab]	0.06±0.02[a]	0.06±0.02[a]	0.07±0.01[a]	
Copper	0.18±0.02[a]	0.14±0.02[ab]	0.09±0.02[c]	0.12±0.02[bc]	0.15±0.02[ab]	0.17±0.02[a]	
Cadmium	ND	ND	ND	ND	ND	ND	
Lead	ND	ND	ND	ND	ND	ND	
Na/K	0.31	0.37	0.46	0.21	0.19	0.26	<1
Ca/P	0.19	0.14	0.13	0.44	0.31	0.29	>1

Mean (±SD) with different superscript in the same row are significantly different at P < 0.05

Key:

A- 100 % plantain flour
B- 98 % plantain flour + 2 % moringa seed flour
C- 96 % plantain flour + 4 % moringa seed flour
D- 50 % plantain flour + 50 % pigeon pea flour
E- 49 % plantain flour + 49 % pigeon pea flour + 2 % moringa seed flour
F- 48 % plantain flour + 48 % pigeon pea flour + 4 % moringa seed flour
ND- not detected

The fat content ranged from 5.39 to 8.20 %. There were no significant differences in the samples except for sample C, though sample D - F had the lowest value may be because of the addition of pigeon pea flour. Crude fibre content ranged from 1.53 to 2.40 %, the high fibre content in food may aid in the digestion of the flour in the colon and reduce constipation (Jideani and Onwubali, 2009). It was observed that as pigeon pea was added the crude fibre increased. The ash content ranged from 2.42 to 2.68 %, but there was no significant difference in the ash content. The ash content of a food may be used as an index of mineral constituents of the food (Sanni *et al*., 2008). The carbohydrate content ranged from 73.12 to 85.12 %. The energy content ranged from 407.97 to 422.66 kcal/g. This implies that this flour blends may be useful as sources of energy.

4.2 Mineral composition of flour blends from unripe plantain, pigeon pea and moringa seed

The mineral composition of the flour blends produced from the unripe plantain pulp, pigeon pea and moringa seed are presented in Table 3. The sodium content ranged from 1.42 to 2.98 mg /100g. There were significant differences in the samples, and it was observed that the sample D-F had the lowest values may be due to addition of pigeon pea. High intake of sodium can lead to hypertension. The potassium, phosphorus, and calcium contents ranged from 5.38 to 7.59 mg/100g, 15.35 to 21.72 mg/100g, and 2.35 to 6.37 mg/100g respectively. It was observed in potassium, phosphorus and calcium increased significantly in the samples with pigeon pea (D-F), though, there was significant difference in all the samples. The most abundant mineral was phosphorus. Phosphorus plays an important role in maintenance and repair of cells and tissues. Also, needed for teeth and bones formation. Potassium is required for proper heart functioning and play a role in skeletal and muscle contraction for normal digestion and muscular function. High potassium in food may help to reduce blood pressure, protect against stroke and prevent osteoporosis. The sodium/ potassium molar ratio ranged from 0.31 to 0.79 mg/100g. It was observed that these values were generally low and meet up with the recommended value of less than 1. WHO/FAO (2004) encouraged diets with low level of sodium and high potassium, which may be suitable for people with high blood pressure. Calcium is needed for maintenance of teeth and bones; it prevents rickets in children and osteoporosis in adults. The calcium/phosphorus ratio ranged from 0.13 to 0.44, these values were low compared with FAO recommended value of more than 1. This revealed that there will be need to fortify this sample with calcium and phosphorus in order to prevent adverse health effect such as bone loss, arterial calcification and death (Adatorwovor *et al*., 2015).

The iron, zinc, manganese and copper content ranged from 0.53 to 0.93 mg/100g, 0.24 to 0.50 mg/100g, 0.20 to 0.70 mg/100g and 0.09 to 0.18 mg/100g respectively. It was shown from the results that there were significant differences in all the samples. Iron plays a role in metabolism as a component of enzymes and some protein. It helps the red blood cells transport oxygen to all parts of the body. Zinc serves as body immune system and metabolism function, helps in wound healing. Manganese plays a role in bone formation, blood clotting and reduce inflammation. Copper aids in maintaining healthy bones, blood vessels, nerves and immune function and prevent cardiovascular diseases. It was observed that cadmium and lead was not detected in all the samples.

4.3 Functional properties of flour blends from unripe plantain, pigeon pea and moringa seed

Functional properties of flour blends produced from unripe plantain pulp, pigeon pea and moringa seed are shown in Table 4. The essence of functional properties determination in food is to identify the usage of the flour in food application or product development. The bulk density ranged from 0.51 to 0.70 g/ml, this agreed with the report of Iwanegbe *et al* (2019) in unripe plantain, soybean and ginger flour blends. The bulk density is very important because it is used to determine packaging requirement for the food (Adebowale *et al*., 2008). The high bulk density has been attributed to high carbohydrate content (Chinma *et al*., 2011). But low bulk density is desirable and advantageous considering the nutrition aspects of the quantity to be consumed (Bala *et al*., 2015). The bulk density is influenced by the structure of starch polymers (loose or tightly packed, low bulk density can be as a result of loose structure of starch polymers (Plaami, 1997) The results obtained agreed with Fadimu *et al* (2018) who obtained 0.68-0.70 g/ml in dried plantain flours. The oil absorption capacity ranged from 1.73 to 2 .26%. The oil absorption capacity is necessary because oil serve as flavour retainer and increases the mouth feel of the food (Aremu *et al*., 2009). The oil absorption capacity is an indication of the rate at which protein binds to fat in food formulation. The water absorption capacity ranged from 2.00 to 2.26 %. Water absorption capacity (WAC) gives indication of the amount of water that could be absorbed for gelatinization. High water absorption can be attributed to lose structure of starch polymer while low water absorption value indicates the compactness of the structure (Adebowale *et al*., 2012; Oladipo and Nwokocha, 2011).

The water absorption capacity (WAC) is very essential in the development of ready to eat food because high WAC may give product cohesiveness while low WAC will be easily digestible (Housson and Ayenor, 2002). The swelling capacity ranged from 4.46 to 5.20% relation to its initial volume. Swelling capacity is an indication of the presence of amylase which influences the quantity of amylose and amylopectin present in foods. The amylopectin is responsible for granule swelling, the higher the amylopectin content in composite flour the increase in the swelling power (Tester and Morrison, 1990). High swelling capacity results in higher associate forces (Ruales *et al*., 1993). The least gelation concentration signifies the point at which the starch present in food starts to gel and this depends on the carbohydrate that is present in the food. The least gelation ranged from 1.06 to 2.06%. The increase in protein concentration improve interaction among the binding forces thus increase the ability of gel of the flour (Lawal, 2004). The lower the least gelation concentration the better the gelling ability of the flour. Also, the higher the least gelation concentration the higher the quantity to be used to form gel. It was observed that all the samples had low values that may be suitable to form good gel. The dispensability ranged from 68.00 to 61.33 %. Dispersibility is an index to measure proper way of rehydration or reconstitution of flour or flour blends with water (Kulkani *et al.*, 1991).

Table 4: Functional properties of flour blends from unripe plantain, pigeon pea and moringa seed

Sample	Bulk density (g/ml)	Water absorption capacity (%)	Oil absorption capacity (%)	Swelling capacity (%)	Least gelation concentration (%)	Dispensability (%)
A	0.52±0.11[c]	2.20±0.00[b]	1.73±0.11[b]	4.46±0.25[c]	1.13±0.11[d]	68.00±0.51[a]
B	0.51±0.01[c]	2.00±0.00[c]	1.80±0.20[b]	5.00±0.20[ab]	1.80±0.00[b]	67.60±1.21[b]
C	0.52±0.01[c]	2.00±0.00[c]	2.06±0.11[a]	5.13±0.05[a]	2.06±0.11[a]	65.33±0.58[c]
D	0.67±0.00[b]	2.40±0.00[a]	1.86±0.11[ab]	4.76±0.11[b]	1.20±0.00[d]	63.61±0.58[d]
E	0.70±0.01[a]	2.26±0.11[b]	1.40±0.00[c]	5.16±0.05[a]	1.06±0.11[d]	62.67±0.58[e]
F	0.70±0.01[a]	2.00±0.00[c]	1.93±0.11[ab]	5.20±0.00[a]	1.53±0.11[c]	61.33±1.14[f]

Mean (±SD) with different superscript in the same column are significantly different at $P < 0.05$

Key:

- A- 100 % plantain flour
- B- 98 % plantain flour + 2 % moringa seed flour
- C- 96 % plantain flour + 4 % moringa seed flour
- D- 50 % plantain flour + 50 % pigeon pea flour
- E- 49 % plantain flour + 49 % pigeon pea flour + 2 % moringa seed flour

F- 48 % plantain flour + 48 % pigeon pea flour + 4 % moringa seed flour

5.0 CONCLUSION

This study revealed that flour blends produced from plantain pulp, pigeon pea and moringa seed possessed significant improvement in their protein, minerals and functional properties. There was a significant increase in the bulk density, swelling capacity and least gelation concentration. This means this blend could be of good use in the development of food product requiring high gelling properties. The Sodium/Potassium ratio of less than one in the blends shows that this blend will serve in ameliorating problems associated with high blood pressure hence will help in the management of people suffering from hypertension. However, the low values of Ca/P ratio less than one show that the products to be developed from the blend has to be supplemented with calcium rich sources.

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CONFLICT OF INTEREST

The authors have no conflict of interest to declare

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