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Nutritive Value of three varieties of banana and plantain blossoms from Cameroon

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ABSTRACT

Background: The by-products of banana and plantain shrubs, especially banana blossom (banana male bud) are usually thrown away by producers in plantations, and produce important quantities of post harvest waste. The nutritional composition of three varieties of banana and plantain blossoms grown in Cameroon; dessert banana (Musa AAA), plantain (Musa AAB) and cooking banana (Musa ABB), was assessed for their potential applications.

Methods: The contents in water, ash, lipids, protids, carbohydrates and crude fibres were determined using standard A.O.A.C methods. The sugar levels were assayed using colorimetric methods, dietary fibres by enzymatic digestion, amino acids by HPLC, fatty acids by gas chromatography and minerals by atomic absorption spectrophotometry.

Results: The results showed that the water content varies from 92.29 (AAA) to 93.73 % F.W. (AAB). The ash content varies from 9.88 (AAB) to 12.25 % D.W. (AAA). The lipid content varies from 4.95 (AAA) to 15.69 % D.W. (ABB) and contains polyunsaturated fatty acids (33.80 - 41.50 g/100g FM), particularly linoleic and gamma linolenic acids. The total protein content varies from 8.89 (AAB) to 10.35 % D.W. (AAA). Leucine, phenylalanine + tyrosine, valine, lysine and threonine are the main essential amino acids (2.75 - 3.30 %). The total carbohydrate content varies from 22.36 (AAA) to 62.19 % D.W. (AAB) and glucose, fructose and sucrose are dominant in the AAB genotype with values of (8.15; 3.04 and 1.35 % respectively). The AAA genotype is rich in total dietary fibres (50.09 %). These banana and plantain flowers are rich in macrominerals. Potassium, calcium, magnesium and phosphorus levels are high in the AAA genotype, with values of (6480; 687; 273; 211 mg/100g D.W., respectively).

Conclusions: These blossoms could be considered as a source of dietary fibres for the control of obesity and diabetes.Further investigations on the composition and the physiological functions (using animal-feeding experiments) of these dietary fibres are to be considered.

LIST OF ABBREVIATIONS

AOAC: Association of Official Analytical Chemists
FM: Fat Matter
FW: Fresh Weight
DW.: Dry Weight
CARBAP: Centre Africain de Recherches sur Bananiers et Plantains
g: gramme
mg: milligramme

INTRODUCTION

Banana and plantain plants are the world's biggest herbs, grown abundantly in many developing countries. Bananas and plantains are one of the most important sources of energy in the diet of people living in tropical humid regions. The plants are stenothermic, cultivated in hot and wet regions, and bear fruits all year round. There are approximately 1200 varieties of bananas all over the world (Kouassi, 2001). Banana is a general term embracing a number of species or hybrids in the genus Musa of the family Musaceae. Almost all of the known edible-fruit cultivars arose from two diploid species, *Musa acuminata* (AA) and *Musa balbisiana* (BB). Moreover, there are diploid, triploid and tetraploid hybrids made up of subspecies of *M. acuminata*, and subspecies between *M. acuminata* and *M. balbisiana* (Stover and Simmonds, 1987; Robinso, 1996). Dessert bananas for world food trade are almost entirely derived from genetic make ups of *Musa acuminata* of triploid character, indicated as AAA. Plantain (*Musa* AAB) and other bananas that can be used for cooking (cooking bananas, *Musa* ABB) are also triploid and derived from the AA.BB hybridization. Plantains and cooking bananas are very similar to unripe dessert bananas in outward appearance, although often larger. The major differences are that their flesh is starchy rather than sweet, they are used unripe, and require cooking. Bananas and plantains constitute the principal food resources in the world. They occupy the Fourth place in the World's most significant foodstuffs after rice, corn and milk (FAO, 1999; INIBAP, 2002). Banana trees are produced in large quantities in tropical and subtropical areas. In Africa, the main producers are Uganda and Cameroon. In Cameroon, the production of bananas and plantains represents the second agricultural economic resource of the country after wood (FAO, 2001). These bananas and plantains are the third most consumed food (Dury *et al.,* 2002) and since 2007 the exportation of bananas and plantains has tripled in Cameroon (Lassoudière, 2007). However, each time one banana stem is produced; one banana blossom is also produced because it is usually harvested together with the banana. These banana blossoms are usually thrown away by producers in plantations and are one of the agricultural by-products which are getting more attention from many researchers and food manufacturers as potentially, a food source. By-products of vegetables and plants are usually discarded post-harvesting or processing, as it was not always needed in the production of food. Although few studies covering all aspects of chemistry by-products of banana have been reported in the literature, recent works has been done on some of these by-products, namely banana peel and have shown that these banana peels are rich in unsaturated fatty acids, antioxidants and good quality protein (Happi Emaga *et al*., 2007). These peels are also rich in starch (35.4 - 39.3 % DW); they are a source of pectin and dietary fibres (40-50 % DW), especially insoluble dietary fibres (Happi Emaga et *al.,* 2008a). In the same way , the characterization of pectins from these banana peels show that they can be used as a therapeutic molecule for diabetes and cardiovascular disease in the sense that pectins reduce blood sugar and cholesterol levels in the blood (Happi Emaga et *al.,* 2008b). However, since there are several recent studies that have reported on food production using these by-products and indicating they can improve the nutritional value, especially the dietary fibre level of the food produced (Wickramarachchi and Ranamukhaarachchi, 2005). Bananas flowers are large, dark purple-red blossoms that grow from the end of a bunch of bananas. They are also called banana inflorescence, banana blossom or banana male bud. They are an agricultural by-product that is often consumed as vegetable in many Asian countries such Malaysia, Indonesia, Sri Lanka, Philippines and other South-East Asian countries (Wickramarachchi and Ranamukhaarachchi, 2005). Despite the fact that they are generally consumed as vegetable, only a few studies have been carried out on their nutritional value and dietary fibre content. There is little mention of their use in literature. Potential applications of these banana blossoms depend on their nutritional composition. However, some papers have dealed with their different therapeutic applications such as the prevention of intestinal cancer (Pari and Maheshwari, 2000; Wickramarachchi and Ranamukhaarachchi, 2005), the treatment of hyperglycemia and type II diabetes through the activation of GLU T1 and T4 carriers (Pasupuleti and Anderson, 2008; Bhaskar *et al.,* 2011). For these reasons, the present research is to bring out other applications for these by-products, in order to make them more useful to farmers of this sector, by determining a detailed nutritional composition of banana and plantain blossoms grown in Cameroon.

MATERIALS AND METHODS

1. Sample preparation

The bananas and plantain blossoms *(photo 1)* used in this study were from three varieties of bananas trees. All the varieties were obtained from the *African Research Centre on Bananas and Plantains* (CARBAP), Cameroon: namely *Lagun Vunalir* of AAA genotype (dessert banana), Zip Ekon of AAB genotype (plantain), and *Pisang Kepok Bung* of ABB genotype (cooking banana). The choice of each variety was done on those which were not used or found in literature. The banana blossoms were washed and separated into particles. They were dried at 55°C for 48 h, and then stored in polypropylene bags in the desiccators before use.

2. Chemical analysis

The water content and the ash content of the banana blossoms were estimated according to standard methods (AOAC, 1980). Total lipids were extracted by continuous reflux in a Soxhlet apparatus (Soxtherm S306 AK Automatic Extractor System branstead electrothermal Gerhardt, Germany) for 8 h, using hexane (boiling range: 60– 80°C). The extracted lipids were heated in an oven at 70°C for 1 h to remove all traces of solvent. The total nitrogen content (N) was determined using the standard Kjeldahl procedure (AOAC, 1980), by nitrogen determination after digestion (with a 1000 Kjeltabs MQ tablet and a Digestion System 20, 1015 Digester, Tecator, AB, Höganäs Sweden) and distillation (using a Kjeltec Auto 1030 Analyser, Tecator, AB, Höganäs, Sweden). Crude protein was expressed as 6.25 x N. The mineral content (concentrations of sodium, potassium, calcium, magnesium, zinc, iron, copper and manganese) were determined using a flame atomic absorption spectrophotometer (Perkin–Elmer, 2380) according to the Benton and Vernon method (Benton and Vernon, 1990). For the phosphorus content, the Murphy Riley reagent method was used (Murphy and Riley, 1962). Total amino acids composition of the banana and plantain blossoms was obtained after hydrolysis under nitrogen with 6 N HCl at 110°C for 24 h (Kaiser *et al.,* 1974) and analyses of the amino acids was done by High Performance Liquid Chromatography, HPLC (Stein and Moore, Biochrom 20 Plus, Pharmacia, Cambridge, UK). Norleucine (500 nM) was added as internal standard. The hydrolysates were injected into a cation-exchange column and the amino acids were separated by elution with suitable buffers of increasing pH, and detected with ninhydrin in a continuous flow photometric analytical system at 570nm and at 440 nm (for proline) and quantified by Sigma calibration standards. Sulphur amino acids (cysteine and methionine) were determined as cysteic acid and methionine sulphone, respectively using an amino acid analyser (Biochrom 20 Plus, Pharmacia, Cambridge, UK). The protein quality of the samples was evaluated using the relationship between total essential amino acids and total non essential amino acids. The Fatty acid composition was determined by gas liquid chromatography (GLC), according to IUPAC Method (IUPAC, 1990). This was done using a Hewlett–Packard 6890 series Gas Chromatograph System equipped with a HP-INNOWAX capillary column (30 m x 0.25 mm, film thickness 0.32 µl). Derived extracts (1.0 µl) in hexane were injected into the column. The oven temperature was programmed from 50 (isothermal for 1 min) to 150°C at 30°C/ min and from 150°C to 240°C (isothermal for 10 min) at 4°C/ min. Compounds were detected using a flame ionisation detector at 325 nm. Helium was used as carrier gas at a flow rate of 65 ml/min. Identification and quantification of fatty acid methyl esters was done by comparing the retention times of the peaks with those of standards of Supelco 37 component FAME Mix 1 ml (Supelco Inc., Bellefonte, PA, USA). Soluble dietary fibre (SDF) and insoluble dietary fibres (IDF) were analysed according to AOAC methods (Prosky *et al.,* (1992). Total dietary fibre (TDF) was calculated as IDF plus soluble dietary fibre (SDF) (Prosky *et al.,* (1992). Briefly, the samples were suspended in buffer, sequentially digested by heat-stable alpha-amylase, protease and amyloglucosidase to remove starch and protein. IDF was recovered from the enzyme digest after filtration. SDF in the filtrate was precipitated with ethanol and filtered. All dietary fibre (DF) fractions collected were dried. These DF contents were corrected for residual protein, ash, and blank. Soluble sugars (glucose, fructose and sucrose) were quantified according to the colorimetric method of Dubois *et al.* (1956). Sucrose, fructose and glucose standards were used for quantification. For these, the samples were homogenized with water for 1 h at 35°C. The extract was filtered through 0.45 µm Millipore filters and the absorbance was read at 490 nm using a spectrophotometer (Thermo Scientific 205). All the analyses were done in triplicate and the data obtained were statistically analysed with IBM SPSS software 20.0 for Windows. One-way Analysis of Variance (ANOVA) test and the Least Significant Difference (LSD) at the critical point 5% was done to compared the different value.

Photo 1: banana blossom

RESULTS AND DISCUSSION

1. Proximate composition

Table 1: Proximate composition (% dry weight, DW)

Genotype	Nutrients			
	Water	Ash	Lipids	Proteins
AAA	92.29 ± 0.45^{c}	12.25 ± 0.14^{a}	4.95 ± 0.11^{c}	10.35 ± 0.50^{a}
AAB	93.73 ± 0.55^{a}	9.88 ± 0.34^{b}	8.81 ± 0.28^{b}	8.89 ± 0.66^{c}
ABB	92.88 ± 0.32^{ac}	10.08 ± 0.20^{b}	15.69 ± 0.38^{a}	10.06 ± 0.43^{ac}

NB: Means with different letter superscripts on the same column are statistically different (P<0.05).

The proximate composition of banana blossoms is showed on Table 1. The water content of the banana blossoms of AAA (Lagun Vunalir), AAB (Zip Ekon) and ABB genotypes (Pisang Kepok Bung) are 92.29, 93.73 and 92.88 % respectively. There is a significant difference ($p<0.05$) between the values of AAA and AAB genotypes. The water content of AAA and AAB is higher than that of AAA (90.58 %) and AAB (89.42 %)) obtained by Sheng *et al.,* (2010) (variety not specified). On the other hand, the water content of the banana blossoms of ABB genotype is similar to that (92 %) obtained by Wickramarachchi and Ranamukhaarachchi, (2005). The water content of food is of great importance in Food Technology, for it makes possible to estimate its lifespan and its mode of preservation.

The ash content of the banana blossoms of AAA (Lagun Vunalir), AAB (Zip Ekon) and ABB genotype (Pisang Kepok Bung) are 12.25 %, 9.88 % and 10.08 % respectively (Table 1). These values represent the percentage of the mineral fraction in food. There is a significant difference ($p<0.05$) between these values and they depend on the genotypes. The AAA and AAB genotype values are higher than those of AAA (1.19 %) and AAB (1.2 %) obtained by Sheng *et al.,* (2010). The value of ABB genotype is slightly higher than that (8.53%) obtained by Wickramarachchi and Ranamukhaarachchi, (2005) for the same genotype. However, the value obtained for AAB is similar to that (10 %) observed by Akubor and Ishiwu, (2013), while the value obtained for AAA is much higher than that (0.5%) obtained by Bhaskar *et al.,* (2012). These differences could be due to the difference in chemical composition of the various genotypes and also due to the difference zones of cultivation.

The lipids contents of the banana blossoms of the AAA (Lagun Vunalir), AAB (Zip Ekon) and ABB genotype (Pisang Kepok Bung) are 4.95 %, 8.81 % and 15.69 % respectively (Table 1). The difference is significant ($p<0.05$) between these values and they depend on the genotypes. The value obtained for AAA is much higher than that (0.4 %) obtained by Sheng *et al.,* (2010), but lower than (12.7 %) obtained by

Bhaskar *et al.,* (2012). Also, the value obtained for AAB is higher than (0.6 %) that obtained by Sheng *et al.,* (2010) and that (4.8 %) obtained by Akubor and Ishiwu, (2013). These also, could be due to differences in the zones of cultivation of these various genotypes, the varietal difference within the same genomic group and the influence of the levels of other macronutrients. In the human organism, lipids have different functions according to their nature and their distribution; hence they can act as energy stores or have a structural role (AFSSA, 2009). However, the lipid content of these samples increases with the letter B of the various genotypes. This could mean that the *Musa balbisiana* (BB) may be richer in lipids than the Genus, *Musa accuminata* (AA). The protein contents of the banana blossoms AAA (Lagun Vunalir), AAB (Zip Ekon) and ABB genotype (Pisang Kepok Bung) are 10.35 8.89 and 10.06 % respectively (Table 1). There is a significant difference ($p<0.05$) between the values of AAA and AAB genotype while that of ABB genotype is similar to these two genotypes. The protein content of the AAA genotype is higher than that (2.07 %) obtained by Sheng *et al.,* (2010) for AAA genotype. On the other hand, it is slightly lower than that (12.5 %) obtained by Bhaskar *et al.,* (2012) for the same genotype. This reveals that in the same genomic group, the protein content can vary according to the various sub-groups of cultivated triploid banana trees. The genomic protein contents of AAB and ABB groups are respectively higher and lower than those obtained (6 % for AAB and 20.54 % for ABB) by Sheng *et al.,* (2010) and Wickramarachchi and Ranamukhaarachchi, (2005). In the same way, the value obtained for AAB genotype is slightly higher than that (7 %) found by Akubor and Ishiwu, (2013). These differences could be explained by the fact that the protein contents depend on the various genomic groups. However, the values obtained (10 %) showed that the banana blossoms of the banana tree of AAA and ABB genotypes can be regarded as source of proteins (FAO, 1970).

2. Total carbohydrates and soluble sugars

The average contents of total carbohydrates, sucrose, glucose and fructose of the banana blossoms are given on Table 2.

Table 2: Total carbohydrates and sugar contents (% dry weight, DW)

Genotype	Sugar constituent			
	Total Carbohydrates	Sucrose	Glucose	Fructose
AAA	22.36 ± 0.52^{c}	0.73 ± 0.33^{ac}	6.53 ± 0.15^{b}	2.20 ± 0.45^{ac}
AAB	62.19 ± 0.50^{a}	1.35 ± 0.33^{a}	8.15 ± 0.17^{a}	3.04 ± 0.45^{a}
ABB	45.73 ± 0.46^{b}	0.03 ± 0.21^{c}	3.81 ± 0.02^{c}	1.24 ± 0.29^{c}

NB: Means with different letter superscripts on the same column are statistically different (P<0.05).

The total carbohydrate contents vary from 22.36 (AAA) to 62.19 % (AAB) and present a significant difference ($p<0.05$) between the various genotypes. The values obtained for AAA and AAB genotypes are lower than those (90.80 % for AAA (Baxijiao) and 90.00 % for AAB (*Paradisiaca*) observed by Sheng *et al.,* (2010). This difference could be explained not only by varietal diversification within the same genomic group, but also by the difference in the various zones of cultivation. The total carbohydrate contents of AAB and ABB genomic groups are higher than those obtained for banana skins (40 % and 29 % respectively) by Mohapatra *et al.,* (2010) in India. The value obtained for AAB genotype is similar to that (62.2 %) observed by Akubor and Ishiwu, (2013). However, the results obtained show that the banana blossoms can be a source of carbohydrates (FAO, 1970).

The sucrose content varies from 0.03 (ABB) to 1.35 % (AAB) (Table 2) and show a significant difference ($p<0.05$) between the various genotypes. The values obtained are lower than those (1.5, 0.2 and 0.4% respectively) of the banana peels of AAA (Large Dwarf), AAB (French Clair) and ABB genotype (pelipita) by Happi Emaga *et al.,* (2007). This shows that peels of AAA and ABB genotype are richer in sucrose than the banana blossoms of the of the same banana tree genotype. On the other hand, the banana blossoms of AAB genotype have more sucrose than its peels. The values obtained show that the male buds of AAA and AAB genotypes can be regarded as source of sucrose (FAO, 1970).

The glucose content of the banana blossoms of AAA (Lagun Vunalir), AAB (Zip Ekon) and ABB genotype (Pisang Kepok Bung) are 6.53, 8.15 and 3.81 % respectively (Table 2).There is a significant difference ($p<0.05$) between these values, and they depend on the genomic groups. These values are higher than those (2 %, 1 % and 0.4 %) of the banana peels of genomic groups, AAA (Large Dwarf), AAB (Big Ebanga) and ABB (pelipita) respectively (Happi Emaga *et al.,* 2007). The results obtained suggest that even within the same genomic group, the glucose level can vary with the various varieties. However, glucose is required by several cells for their survival, the

reactions of energy production in the form of ATP as well as the synthesis of various macromolecules containing this sugar (Bhaskar *et al.,* 2011).

The fructose contents of the banana blossoms of AAA (Lagun Vunalir, 2.20 %,), AAB (Zip Ekon, 3.04%) and ABB genotype (Pisang Kepok Bung, 1.24 %) are reported on Table 2. There is a significant difference ($p<0.05$) between these values and they depend on the genotype. These values are higher than those (1.2 %, 2.2 % and 0.1 %) of the banana peels of AAA (Large Dwarf), AAB (Big Ebanga) and ABB (pelipita) genotype respectively (Happi Emaga *et al.,* 2007). This suggests that the banana blossoms of AAA, AAB and ABB genotype contain more fructose than the banana peels of the same genotype. However, the glucose and fructose levels for AAA and AAB genomic groups corroborate the hypothesis that the banana blossoms of these two genomic groups could be a source of simple sugars (Sheng *et al.*, 2010).

3. Amino acids composition

The essential and non essential amino acids composition of the banana blossoms of the various genomic groups is given on Table 3. This reveals that the banana blossoms of AAA (Lagun Vunalir), AAB (Zip Ekon) and ABB genotype (Pisang Kepok Bung) contain all the essential amino acids when referred to the classification of the FAO/WHO Committee (FAO/WHO, 2001).Tryptophan was destroyed during acid hydrolysis. The essential amino acid contents vary from 2.76 % (AAA genotype) to 3.27 % (ABB genotype) and present a significant difference ($p<0.05$).

Table 3: Amino acid composition (% dry weight, DW)

Amino acids	**Genotypes**		
Essential amino acids	AAA	AAB	ABB
Leucine	0.51 ± 0.00^{c}	0.61 ± 0.00^{b}	0.63 ± 0.00^{a}
Valine	0.44 ± 0.00^{c}	0.49 ± 0.00^{b}	0.52 ± 0.01^{a}
Lysine	0.36 ± 0.00^{c}	0.38 ± 0.00^{ac}	0.44 ± 0.02^{a}
Threonine	0.33 ± 0.00^{c}	0.38 ± 0.00^{b}	0.40 ± 0.00^{a}
Phénylalanine + Tyrosine	0.47 ± 0.00^{c}	0.52 ± 0.00^{b}	0.55 ± 0.00^{a}
Isoleucine	0.29 ± 0.00^{c}	0.35 ± 0.00^{b}	0.37 ± 0.00^{a}
Histidine	0.22 ± 0.00^{a}	0.23 ± 0.00^{a}	0.23 ± 0.01^{a}
Méthionine + Cystéine	0.14 ± 0.02^{a}	0.12 ± 0.00^{c}	0.13 ± 0.00^{ac}
$\sum_1$	2.76	3.08	3.27
Non essential amino acids			
Glutamate	1.19 ± 0.01^{ac}	1.18 ± 0.01^{c}	1.27 ± 0.02^{a}
Aspartate	0.68 ± 0.00^{c}	0.71 ± 0.00^{ac}	0.72 ± 0.01^{a}
Serine	0.40 ± 0.00^{c}	0.43 ± 0.00^{b}	0.45 ± 0.00^{a}
Alanine	0.36 ± 0.00^{c}	0.41 ± 0.00^{b}	0.45 ± 0.00^{a}
Arginine	0.36 ± 0.00^{c}	0.38 ± 0.01^{ac}	0.40 ± 0.00^{a}
Glycine	0.31 ± 0.00^{c}	0.36 ± 0.00^{a}	0.37 ± 0.00^{a}
Proline	0.26 ± 0.01^{c}	0.30 ± 0.00^{a}	0.31 ± 0.00^{a}
Cystine	0.03 ± 0.00^{a}	0.03 ± 0.00^{a}	0.03 ± 0.00^{a}
$\sum_2$	3.59	3.80	4.00
$\sum = \sum_1 + \sum_2$	6.35	6.88	7.27
$\sum_1/\sum_1 + \sum_2$ (A)	0.43	0.45	0.45

NB: Means with different letter superscripts on the same row are statistically different ($p<0.05$).
$\sum 1$= sum of the essential amino acids; $\sum 2$=sum of the non essential amino acids; A= $\sum_1/\sum_1 + \sum_2$.

The essential amino acid contents obtained are higher than those (1.7 - 2.6 %) observed by Happi Emaga *et al.,* (2007) on the peels of the same banana genotype with different varieties. Hence, these values obtained corroborate those observed by Sheng *et al.,* (2010), who noticed that banana blossoms contained all the essential amino acids. From Table 3, the amino acids, methionine + cysteine present the lowest content and so they are the limiting amino acids. Amongst the three genotypes, the ABB genotype (Pisang Kepok Bung) has the highest levels of essential amino acids and the dominating essential amino acid is leucine. The banana blossoms of AAA genotype have the lowest value (0.43) of the ratio of the sum of essential amino acids to sum of total amino acids (A), while those of AAB and ABB genotypes present the highest value (0.45).This ratio (A) shows that the banana blossoms of AAB and ABB genotypes have a high percentage of essential amino acids than those of AAA genotype. However, FAO/WHO (FAO/WHO, 2007) recommend on average, 1.2 to 2.3 %/Kg/day contribution in essential amino acids in children from 6 to 12 months. This suggests that the powders of these banana blossoms could be introduced like food supplements into the pap of these children in order to enrich their feeding.

The non essential amino acid contents vary from 3.59 (AAA) to 4.00 % (ABB genotype) and present a significant difference ($p<0.05$) between these values. The contents observed are respectively higher and lower than those (2.7 % for AAA and 5.5 % for ABB) observed by Happi Emaga *et al.,* (2007) in the banana peels of the same genotype with different varieties. As observed by this last author, the ABB genotype shows the highest value of non essential amino acids. However, the quantity of protein was much higher than the sum of the amino acids. This could be explained by the fact that the Kjeldahl method used here, determines all N compounds, not only proteins or amino acids, which leads to an over estimation of the protein content. There exist other N compounds than protein. (Kanazawa and Sakakibara (2000); Someya *et al.,* (2002)) have for example, shown that banana by-products contain large quantities of antioxidants (1% DM), e.g. dopamine.

4. Fatty acid Composition

The fatty acid composition of the oils extracted from the banana blossoms expressed as a percentage of the fatty matter (FM) is reported on Table 4. This reveals that the saturated fatty acid contents of AAA (Lagun Vunalir), AAB (Zip Ekon) and ABB genotype (Pisang Kepok Bung) are 57.92 %, 53.31 % and 57.17 % respectively. There is a significant difference ($p<0.05$) between these values, and the genotype AAA is dominating. Among the saturated fatty acids obtained, palmitic acid is the most abundant, followed by stearic, behenic, lignoceric and arachidic acids in smaller quantities. The values of saturated fatty acids obtained for the three genotypes are higher than those (51.9, 46.6 and 41.1 %) observed by Happi Emaga *et al.,* (2007) for the banana peels of AAA (Large Dwarf), AAB (Big Ebanga) and ABB (pelipita) respectively, collected from the same area of cultivation (CARBAP).This observation shows the difference in chemical composition between by-products of the banana trees of the same genotype, and confirms the varietal difference within the same genomic group.

Table 4: Fatty acid composition (g/100g FM)

Fatty acid	Genotype		
	AAA	AAB	ABB
Myristic acid (C14:0)	0.00 ± 0.00^{a}	0.23 ± 0.00^{a}	0.00 ± 0.00^{a}
Pentadeconoic acid (C15:0)	0.00 ± 0.00^{a}	0.90 ± 0.00^{a}	0.00 ± 0.00^{a}
Palmitic acid (C16:0)	36.93 ± 0.16^{c}	34.97 ± 0.23^{b}	41.93 ± 0.63^{a}
Stearic acid (C18:0)	9.73 ± 0.03^{a}	5.17 ± 0.03^{b}	4.47 ± 0.03^{c}
Arachidic acid (C20:0)	2.20 ± 0.00^{b}	2.17 ± 0.03^{b}	2.67 ± 0.03^{a}
Behenic acid (C22:0)	5.30 ± 0.00^{b}	5.57 ± 0.03^{a}	4.00 ± 0.10^{c}
Lignoceric acid (C24:0)	3.76 ± 0.36^{a}	4.30 ± 0.00^{a}	4.10 ± 0.20^{a}
% Saturated fatty acids	57.92	53.31	57.17
Myristoleic acid (14:1)	0.00 ± 0.00^{a}	0.67 ± 0.33^{a}	1.20 ± 0.60^{a}
Oleic acid (18:1)	8.63 ± 0.06^{a}	4.77 ± 0.03^{b}	6.80 ± 0.10^{c}
% Monounsaturated fatty acids	8.63	5.44	8.00
Linoleic acid (C18:2)	28.17 ± 0.13^{b}	32.30 ± 0.20^{a}	29.13 ± 0.36^{b}
Gamma linolenic acid (C18:3)	5.63 ± 0.06^{c}	9.20 ± 0.00^{a}	6.60 ± 0.10^{b}
% Polyunsaturated fatty acids	33.80	41.50	35.73

NB: Means with a different letter superscripts on the same row are statistically different ($p<0.05$).

The monounsaturated fatty acid contents of the banana blossoms vary from 5.44 (AAB) to 8.63 % (AAA genotype) and mainly consists of oleic acid. As observed with the saturated fatty acids, the monounsaturated fatty acid levels are also higher than those (4.2 % for AAA, 4.1 % for AAB and 4.6 % for ABB) obtained for banana peels by Happi Emaga *et al.,* (2007). Oleic acid is an energy reserve for fats in a semi-fluid state. It is also a precursor of polyunsaturated fatty acids under the action of the desaturases (AFSSA, 2009). The polyunsaturated fatty acid contents of the banana blossoms of AAA (Lagun Vunalir), AAB (Zip Ekon) and ABB genotype (Pisang Kepok Bung) are 33.80, 41.50 and 35.73 % respectively (Table 4).There is a significant difference ($p<0.05$) between these values and AAB has the highest value. The polyunsaturated fatty acids obtained from the extracted oils are n-6 (omega-6) series and especially linoleic acid. The linoleic acid values obtained for the three genotypes are higher than those (22.7 %, 23.9 % and 22.5 %) observed by Happi Emaga *et al.,* (2007) for banana peels of AAA (Large Dwarf), AAB (Big Ebanga) and ABB (pelipita) genotype respectively, collected from the same area of cultivation (CARBAP). Linoleic acid is an essential fatty acid which cannot be synthesized in the organism. It can only be got from food. Its metabolism generally leads to cellular differentiation and production of hormones such as prostaglandin, which is a reproductive hormone (Ramadan and Mörsel, 2002). The FAO/WHO (2003) recommends an intake of 3 - 4.5 %/day of polyunsaturated fatty acids (omega-6) in children of 6 to 12 months. This suggests that the powders of these blossoms could be introduced like food supplements into the food of these children for a better balanced diet. However, polyunsaturated fatty acids are very important in food because of their roles in nervous, retinal and cerebral

development, in the synthesis of biologically active molecules, the inflammatory process and in the genic regulation (Gil *et al.,* 2012).They are involved in the mechanisms associated with protection against the ignition, the appearance of the metabolic syndrome and with the primary and secondary prevention of much degenerative and cardiovascular pathology (AFSSA, 2010).

5. Dietary Fibre Composition

Table 5: Dietary fibre composition (% dry weight, DW)

Genotype	Dietary fibres		
	Insoluble dietary fibre (IDF)	Soluble dietary fibre (SDF)	Total dietary fibre (TDF)
AAA	45.28 ± 0.31[a]	4.80 ± 0.58[a]	50.09 ± 1.34[a]
AAB	9.40 ± 0.42[c]	0.82 ± 0.06[b]	10.23 ± 0.72[c]
ABB	16.94 ± 0.45[b]	1.54 ± 0.09[b]	18.44 ± 0.81[b]

NB: Means with different letter superscripts on the same column are statistically different (P<0.05).

The total dietary fibre (TDF), insoluble dietary fibre (IDF) and soluble dietary fibre (SDF) contents are given on Table 5. The composition of insoluble dietary fibre (IDF) of the banana blossoms of AAA (Lagun Vunalir), AAB (Zip Ekon) and ABB (Pisang Kepok Bung) genotype is respectively 45.28 %, 9.40 % and 16.94 % (Table 5).There is a significant difference ($p<0.05$) between these values, and genotype AAA is dominating. The content of insoluble dietary fibre of AAA genotype is lower than that (58.3 %) obtained by Bhaskar et a*l.,* (2012) on the same genotype (variety: Elakki Bale). The contents of IDF obtained for AAB and ABB genotypes are lower than those (29.7 % and 29.2 %) observed in banana peels (Happi Emaga *et al.,* 2007). These banana blossom fibres (IDF) might possibly have positive effects on intestinal regulation and stool volume, which are related to the consumption of insoluble fibre (Schneeman, 1987). The AAA genotype also had the highest SDF content (4.80 %) while AAB and ABB genotype had a SDF content of 0.82 % and 1.54 % respectively (Table 5). The SDF content of AAA is lower than that (7.3 ± 0.2) obtained by Bhaskar *et a*l*.,* (2012) for the same genotype but different variety (Elakki Bale). In the same light, the values obtained for the three genotypes (AAA, AAB and ABB) are lower than those (7, 6.2 and 8.1 %) obtained by Happi Emaga *et al.,* (2007) for the banana peels of AAA (Large Dwarf), AAB (Big Ebanga) and ABB (pelipita) respectively. The TDF levels range from 10.23–50.09%, and are higher in the banana group than in plantain. The highest values are observed in the AAA genotype (Lagun Vunalir) (Table 5). The value obtained for AAA is higher than that (4.96 %) obtained by Sheng *et al.,* (2010). This could be due to the difference in variety observed within the same genomic group and also the ecological differences in the different areas of cultivation.

6. Macromininerals and Microminerals composition

The minerals are classified into two major groups: the macrominerals and microminerals (trace elements). The macrominerals composition expressed in mg/100g, DW shows that potassium, calcium, phosphorus and magnesium were high (Table 6). Potassium (5016.6 – 6480 mg/100g DW) was the most abundant macromineral in the bananas blossoms of the three genotypes, followed by calcium, magnesium and phosphorus. The results obtained for the three genotypes (AAA, AAB and ABB) are higher than those observed by Sheng *et al.,* (2010) and Wickramarachchi and Ranamukhaarachchi, (2005). The AAA genotype had the highest calcium content while ABB had the lowest. Happi Emaga *et al.,* (2007) have also shown that banana peels had a higher potassium content than calcium, phosphorus and magnesium.

Table 6: Macrominerals composition (mg/100g, DW)

Genotype	Macrominerals				
	Ca	P	Mg	K	Na
AAA	687 ± 0.00[a]	211 ± 0.00[c]	273 ± 0.00[a]	6480 ± 0.01[a]	4.7 ± 0.00[c]
AAB	570 ± 0.00[b]	217 ± 0.00[b]	211.3 ± 0.00[c]	5246.6 ± 0.05[b]	6.4 ± 0.00[a]
ABB	482 ± 0.00[c]	296.6 ±0.00[a]	232 ± 0.00[b]	5016.6 ± 0.04[c]	5.1 ± 0.00[b]

NB: Means with different letter superscripts on the same row are statistically different (P<0.05).

In the organism, phosphorus is closely related to calcium, for both contribute to the formation and the solidification of bones. Food is "good" if the Ca/P ratio is at most equal to 0.5. This increases the absorption of calcium in the small intestine (Olaofe *et al.,* 2009). This ratio is higher than 0.5 (3.25 for AAA, 2.62 for AAB and 1.62 for ABB) in the banana blossoms suggesting rather, an average absorption of the calcium they contain. The consumption of these banana blossoms is to be encouraged calcium deficient individuals, even if they do not live in areas of great supply of bananas blossoms.

Table 7: Microminerals composition (mg/100g, DW)

Genotype	Microminerals			
	Fe	Zn	Cu	Mn
AAA	158.13 ± 1.84^{ac}	22.53 ± 0.23^{a}	5.43 ± 0.01^{a}	46.60 ± 0.34^{a}
AAB	166.16 ± 4.56^{a}	17.20 ± 0.05^{c}	3.07 ± 0.00^{b}	37.30 ± 0.00^{b}
ABB	151.26 ± 4.21^{c}	22.52 ± 0.05^{a}	3.07 ± 0.00^{b}	32.46 ± 0.80^{c}

NB: Means with different letter superscripts on the same row are statistically different (P<0.05).

The trace elements, in descending order of quantity, were Fe (151 – 166.16), Mn (32 – 46.40), Zn (17 – 22.53) and Cu (3 – 5.43 mg/100g DW). These values are lower for AAA genotype (56.4 mg/100g DW) and higher (ABB) than those (0. 01 mg/100g DW) observed by Sheng *et al.,* (2010) and Wickramarachchi and Ranamukhaarachchi, (2005). This may be due to differences in varieties and environmental factors. The biological roles of a number of trace elements have been reported. Mn and Fe are essential minerals for both plants and animals (Valkovic, 1978). Some of these minerals serve as prosthetic groups of some enzymes.

CONCLUSION

This study was carried out in order to determine the nutritional composition of blossoms of three varieties of bananas and plantains grown in Cameroon. The results show that banana blossoms have a high content of dietary fibre, mainly insoluble dietary fibre (IDF). They could therefore be used as a source of fibres in controlling obesity and diabetes. They could also be exploited to prepare higher added value products such as the lignocellulose fractions. They also have good levels of total carbohydrates and could therefore be used in the treatment of energetic deficiency or be utilized in Food technology to give foodstuffs a specific sensorial quality. All the genotypes have high levels of unsaturated fatty acids especially linoleic and gamma-linolenic acids; they could be exploited to avoid atherome formation that leads to arteriosclerosis. For minerals, potassium, calcium and iron are the most abundant; they could be used to sort out micronutrient deficiency knowing that the prevalence within 1-to-5 year children in Cameroon reaches 47.4%. In some of the nutrients a significant difference was observed between the dessert banana (AAA), cooking banana (ABB) and plantain (AAB) groups. These banana and plantain blossoms also have a good protein quality and could also be used in livestock feed formulations. From their nutritional composition, these banana blossoms could be classified as: Genotype AAA (Lagun Vunalir) > Genotype AAB (Zip Ekon) > Genotype ABB (Pisang Kepok Bung). They are therefore not to be regarded as ‘‘waste’’, as is the current practice in Cameroon.

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