Proximate analysis characteristics of flours obtained from Papocho and Pelipita plantains (*Musa* ABB Simmonds)

Características del análisis proximal de harinas obtenidas de frutos de plátanos variedades Papocho y Pelipita (Musa ABB Simmonds)

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Abstract

Untreated raw flours obtained from fruits of non-commercial plantain varieties Papocho and Pelipita (*Musa* ABB Simmonds) at different stages of development were subjected to proximate analysis and its possible use as food raw material was analyzed. Comparative results showed that the contents and percentages of crude fiber in Papocho varied from 2.54 to 1.37% and Pelipita between 6.45 and 0.88%, crude protein in Papocho between 6.70 and 3.81% and Pelipita between 2.74 and 1.89%, ash in Papocho between 3.66 and 2.41% and Pelipita between 2.43 and 2.10%, and were affected ($P < 0.05$) by the stage of fruit development; while plantain variety affected fat contents in Papocho between 0.64 and 0.48% and Pelipita between 0.55 and 0.35% in both flour samples. In Pelipita variety low moisture content (9.85%) was found and the highest total carbohydrate content (85.86%) was registered at 77 days after flowering.

Key words: Chemical properties, *Musa* ABB, papocho plantain, pelipita plantain, plantain flour.

Resumen

En el estudio se hizo un análisis proximal de las harinas crudas sin tratar obtenidas de frutos de las variedades de plátano Papocho y Pelipita (*Musa* ABB Simmonds) no comerciales en diferentes etapas de desarrollo y se analizó su posible uso como materia prima alimenticia. Los resultados comparativos mostraron que los contenidos y porcentajes de fibra cruda en Papocho variaron entre 2.54 y 1.37% y en Pelipita entre 6.45 y 0.88%, la proteína cruda en Papocho entre 6.70 y 3.81% y en Pelipita entre 2.74 y 1.89%, la ceniza en Papocho entre 3.66 y 2.41% y en Pelipita entre 2.43 y 2.10%, y fueron afectados ($P < 0.05$) por la etapa de desarrollo de la fruta; mientras que la variedad de plátano afectó los contenidos de grasa en Papocho entre 0.64 y 0.48% y en Pelipita entre 0.55 y 0.35% en la harina de ambas variedades. En la variedad Pelipita el contenido de humedad (9.85%) fue bajo. y presentó el mayor contenido de carbohidratos (85.86%) a 77 días después de la floración.

Palabras clave: Composición química, harina de plátano, Musa ABB, plátano papocho, plátano pelipita.

Introduction

Cultivated edible plantains are hybrids or clones which genetic classification is based on both parental species *Musa acuminata* Colla (genome A) and *Musa balbisiana* Colla (genome B) and can be di-, tri- or tetrapolids with a chromosome set of n = 11 (Aurore *et al.*, 2009). Triplods come from the *M. acuminata* (AA) and *M. balbisiana* (BB) crossing and comprise the edible plantains and bananas (Happi *et al.*, 2007).

Papocho and Pelipita (*Musa* ABB Simmonds) varieties are characterized by their distribution in thermal floors between 0 and 2000 MASL, between 22 and 29 °C; they have wide tolerance to low soil fertility conditions and drought and, are resistant to diseases like yellow Sigatoka and black leaf streak (Silva, 2005), also they have high starch content and organic acids in the pulp due to the dominance of the Balbisiana genome (Cayón *et al.*, 2000). At the Caribbean region of Colombia, the Papocho and Pelipita plantains do not have commercial offer and are used by farmers as food (Echeverry, 2001) which limits the access of other population groups to a highly nutrient food, especially with high carbohydrate levels (Nwkocha and Williams, 2009).

An indicator of plantain maturity is the time passed by between anthesis or flowering onset till harvesting, which is known as days after flowering (DAF) (Dadzie and Orchard, 1997). In India, Goswami and Borthakur (1996) found that the Kachkal plantain (ABB) has high nutrient levels at early stages of fruit development, which are reduced with age; however, at these stages the high enzymatic activity and ethylene production accelerate the senescence of the harvested fruit (Cayón *et al.*, 2000) and, consequently, its deterioration limiting its commercial use (Dadzie and Orchard, 1997; Kader, 2002). The main objective of food processing is the exploitation of a raw material that is cheap, highly durable and with high amounts of valuable nutrient compounds, in order to reduce potential costs and avoid its deterioration (AbiodunSolanke y Falade, 2011), making a priority the search for new alternatives that increase its preservation (Yomeni *et al.*, 2004).

The conversion of compound flour is a process that reduces the degradation of plantain fruits (Mohapatra *et al.*, 2009), since its low humidity levels prevent the attack of bacteria and fungi (Butt *et al.*, 2004) and during the transformation process the enzymatic activity is reduced which is responsible of the senescence in climacteric products (Arisa *et al.*, 2013). Although there is a high number of studies in the composition of hybrid varieties of musaceas, only few refers to flour production. In Colombia, Morales *et al.* (1998) made a historical recount for simple flours from different musacea hybrids for the Coffee area (Central region of Colombia) and found that most of the research was concentrated in this particular region and, there is not research on the post-harvesting management and production of compound flour from the cultivated varieties in the Caribbean region. The objective of this study was to evaluate the food value of flours and estimate the degree of use of the pulp from fruits at different days from anthesis till harvesting in the plantain varieties Papocho and Pelipita.

Materials and methods

Collection site and post-harvesting management of the clusters

Samples for the study were collected at the rural zone of the town San Juan de Urabá (8° 44' 0.38" N, 76° 33' 35.3" W), department of Antioquia, localized at the North coast of Colombia, at 2 MASL, with an annual average temperature of 28 °C, annual average precipitation of 1900 mm and average relative humidity of 80% (Salgado and Cadavid, 2004; Pérez and Vargas, 2005). Ten clusters of each plantain variety (Papocho and Pelipita) were used, harvested, collected and wrapped properly according to the methodology AOAC 920.149c (AOAC, 1997). For both varieties this procedure was done at 70, 77, 84, 91 days after flo-

wering (DAF) and 98 DAF for the Papocho variety only. In each DAF the fruits were identified following the universal color code (Table 1). The code was used as labels placed on each branch immediately after anthesis, which allowed the harvesting of the material of the respective DAF, as suggested by Gowen (1995) and Dadzie and Orchard (1997).

Table 1. Color universal code used for plantains of the varietiesPapocho and Pelipita, at different days after anthesis (DAF).

DAF	Color	DAF	Color
7	Red	56	Blue
14	Brown	62	Beigeo
21	Black	70	Gray
28	Orange	77	Red
35	Green	84	Brown
42	Yellow	91	Black
49	White	98	Orange

To counteract the ethylene effect on fruit maturation (Cayón *et al.*, 2000), the clusters were separated in hands *in situ* after harvesting and stored in aerated boxes to avoid the ethylene action in packing; then, fresh samples were stored in an industrial refrigerator at 6 °C temperature placing paper bags with potassium permanganate next to the fruits in order to absorb the ethylene gas (Gowen, 1995).

Measurement of humidity in fresh samples

In the fresh pulp was determined the humidity content using the modified method AOAC 934.06 (AOAC, 1997). Pre-stored fruits were subjected to washings in commercial sodium hypochlorite solution (10 ppm) before peeling. The pulp was sectioned in slices < 0.5 mm using a commercial slicer. Between 5 and 10 g of sample were weighted and subjected to drying for 6 h ((70° ± 1°C under pressure ≤ 100 mmHg (13.3 kPa)) on a ThermoScientific® 29 vacuum oven. In the desiccation process were used two 1000 ml filter flasks (vacuum distiller) packed with commercial silica gel. Samples were cooled down in the desiccator before being weighted.

Compound flour preparation

To obtain starch rich flour the modified craft method of Afanador (2005) was used. Fruits were submerged and washed in commercial sodium hypochlorite solution (10 ppm) and then, were heated up on an oven at 70 °C for 30 min in order to favor starch gelatinization and avoid reduction in particle size and formation of obscure and viscous substances, mainly attributed to pectin and mono- and biphenyl-oxidase enzymes (Afanador, 2005). Fruits of each variety and DAF, once removed from the oven, were separated from the skin to extract the pulp that was cut in slices < 0.5 mm thickness using a commercial slicer. Later, they were placed on a convection oven at 60 °C for 24 h, after that they were process on a commercial grinder with shears (Corona®). Then, the resulting products were mixed to get compound flours of each DAF and packed in previously labelled Zyploc® bags.

Proximal analysis of the compound flour

All the used procedures for this analysis were normalized methodologies of the AOAC. It was determined humidity content (AOAC 977.11), protein by Kjeldahl (AOAC 955.04), ashes (AOAC 942.05), fat (AOAC 920.39) and fiber (AOAC 962.09) (AOAC, 1997). The determination of the total carbohydrate content was done by indirect calculation using the equation proposed by Abadía *et al.* (2002):

$$\%CT = 100 - (\%H + \%G + \%C + \%F + \%Pc)$$

where, *%CT* = total carbohydrate percentage , *%H* = humidity percentage in the sample; *%G* = fat percentage; *%C* = ashes percentage; *%F* = raw fiber percentage and *%Pc* = protein percentage.

Experimental design and statistical processing of the data

Treatments were distributed in the lab on a completely randomized design with factors: varieties Papocho and Pelipita and five DAF. Humidity measurements in the fresh sample were done in triplicate and the proximal analysis was done by duplicate in the flour. The results of the measurements were subjected to statistical treatment by using the SAS/ STAT® v. 9.2 2008; analysis of variance and the validation of

normality and homogeneity of variances for each parameter was performed according to the experimental design used. Then, a mean comparison test was done by the multiple range Duncan´s test by variety and by DAF.

Results and discussion

Humidity content in fresh samples

Differences were observed (P < 0.05) between varieties, DAF and the interaction between variety and DAF, indicating that the values of this characteristic depend largely on the developmental stage in which the fruit and the variety are. In general, through the time it was observed a reduction in humidity content between anthesis and harvesting (Table 2), which agrees with the results obtained by Goswami and Borthakur (1996), Morales *et al.* (1998) and Cayón *et al.* (2000) in pulp of plantain ABB. According to Dadzie and Orchard (1997) this natural phenomena depends on the clone nature, since they are hybrids that depend on culture. Morales *et al.* (1998) found that the ABB clones have the highest accumulation of fresh matter, among other musacea clones.

Table 2. Single effects and interaction between variety and days after anthesis (DAF) on the humidity levels (%) (g/100g of pulp) in fresh samples of plantains from the Papocho and Pelipita varieties.

DAF	Variety		Interaction effect V x DDF
	Papocho	Pelipita	
70	72.37 a†	62.03 a	*
77	71.61 b	61.22 b	*
84	70.36 c	60.88 c	*
91	67.89 d	60.28 d	*
98	67.18 a	–	*
Aver.	69.89 a	61.10 b	

† Averages with the same letter in the same column are not significantly different, according to the Duncan's multiple range test (P ≤ 0.05).
* Significant interaction (P ≤ 0.05)

Proximal analysis of the compound flour

Humidity. The highest dry matter yield (DM) were found in pulp of the Pelipita variety (Table 3). The humidity percentage was different (P < 0.05) between varieties but, did not change between DAF. This trait showed the lowest values in the Pelipita variety. Humidity percentages in flours of both varieties were lower than the ones found by Egbebi and Bedemosi (2011) in flour plantain (*Musa* AAB) at the beginning of ripening (38.5%).

The values found for Papocho variety are consistent with the ones obtained by Morales *et al.* (1998), but, differ to the ones obtained for Pelipita variety. These researchers found DM percentages for Pelipita's flour from 11.7% till 9.3% after 20 and 100 DAF, respectively. The lowest humidity content for Pelipita increases its preference for food use due to its low expiration, lower attack of insects and fungi and easiness of use for bakery (Butt *et al.*, 2004).

Raw fat. The highest percentage of fat was found in the Papocho variety at 98 DAF; although differences in the fat content were found (P < 0.05) between both varieties, the same did not happen for DAF (Table 3). This result is contrasting with the ones of Ayo-Omogie *et al.* (2010) in flours of Cardaba plantains (*Musa* ABB), because they found that the raw fat content significantly correlated with the fruit developmental stage. On the other hand, the results in this study show that the fat content in flours were higher than the ones reported by Egbebi and Bademosi (2011), who found 0.2% contents for green plantain flour. The values of ethereal extract found in this study with flours of Papocho and Pelipita plantains are in the 0.2% - 0.6% range found by Morales *et al.* (1998).

Raw fiber. Significant differences were found for the parameter fiber by DAF and for the interaction variety x DAF, which may infer that for each DAF the net fiber values are not the same and depend on the specific variety, a similar result to the one found by Ayo-Omogie *et al.* (2010), however, there are no highly significant differences for the variety factor, thus, the fact that the plantain is from one variety or another do not affect the fiber yields (Table 3). This finding agrees with the results of Morales *et al.* (1998), who quantified the fiber contents on both varieties and

Table 3. Effect of the variety and the time (days) after anthesis (DAF) on some characteristics (%) of flours obtained from the plantain varieties Papocho and Pelipita.

Characteristics	DAF										Interaction effect		
	70		77		84		91		98				
	Pap.[a]	Pel.	Pap.	Pel.	Pap.	Pel.	Pap.	Pel.	Pap.	Pel.	Var.	DAF	VxDAF
Humidity	11.66 a†	9.25 a	10.96 a	8.1 a	11.04 a	9.85 a	10.03 a	8.43 a	10.53 a	_	*	ns	ns
Fat	0.48 a	0.55 a	0.58 a	0.35 a	0.50 a	0.36 a	0.64 a	0.36 a	0.64 a	_	*	ns	ns
Fiber	2.23 a	6.45 a	1.49 b	1.19 b	2.54 b	0.88 b	1.57 b	1.66 b	1.37 b	_	ns	*	*
Protein	6.70 a	2.35 a	4.89 ba	2.18 ba	4.77 ba	2.40 ba	3.81 b	2.80 b	4.01 ba	_	*	*	*
Ashes	2.41 c	2.43 c	2.80 b	2.32 b	3.65 a	2.10 a	2.85 b	2.33 b	2.92 a	_	*	*	*
Carbohydrate	76.53	78.96	79.26	85.86	77.49	84.42	81.11	84.44	80.53	_	_	_	

a. Pap. = Papocho variety. Pel. = Pelipita variety.

† Averages with the same letter in the same file are not significantly different, according to the Duncan's multiple range test ($P \leq 0.05$).ns: No significant interaction; *: Significant interaction ($P \leq 0.05$).

did not find large differences. For the Papocho variety, yield was between 3.0% and 1.6%, whereas for Pelipita changed between 2.3% and 3.0% in the same studied interval.

Yield fiber obtained for both plantain flour types are higher than the ones found by Ayo-Omogie *et al.* (2010) (0.80% - 0.93%) but, only at 70 and 77 DAF. The same happens when they are compared to the value (0.7%) reported by Egbebi and Bademosi (2011).

Raw protein. This trait changed by the effect of the variety, DAF and the interaction between both varieties (Table 3). The higher protein yield was obtained for the Papocho variety at 70 DAF. The protein yield reached in the flour of this variety are higher than the ones found by Ayo-Omogie *et al.* (2010) and Egbebi and Bademosi (2011) at early stages in the fruit development and, by Pacheco *et al.* (2008) in dried flours of Harton plantain.

It is important to highlight the raw protein content in the Papocho variety, these varied between 4 and 6.7% and were higher than the historical average between 3.1 and 2.2% obtained for the coffee area of Colombia (Morales *et al.*, 1998). On the other hand, the low protein yield in the flour of the Pelipita variety can be explained by the effect of saline stress on the crops (Kong-ngern *et al.*, 2005) because the crops were placed close to the sea.

Total ashes. This characteristic varied because of the effect of the variables included in the study and their interactions (Table 3). The total ashes values were higher than the ones found by Ayo-Omogie *et al.* (2010) in all the fruit development stages and the ones reported by Pacheco *et al.* (2008); however, they were lower than the ones found (3.8%) by Egbebi and Bademosi (2011) and the historical 2.7 – 4.4% for Papocho variety and2.3 – 4.1% for Pelipita reported by Morales *et al.* (1998).

Total carbohydrate. Pelipita variety presented the highest carbohydrate contents through the time of the study (Table 3), being the highest value 85.86% at 77 DAF. For the flour of Papocho variety this value was 81.11% at 91 DAF.

The total carbohydrate contents found for the Papocho flour are consistent with the historical values from Morales *et al.* (1998). However, for the case of Pelipita's flour the results obtained were higher than the ones reported by these authors (between 67% and 83.4% at 20 and 100 DAF, respectively). On the other hand, the carbohydrate contents varied between 78.9% and 85.9% at 70 and 77 DDF, respectively (Table 3). The high carbohydrates values are higher than the ones obtained by Pacheco *et al.* (2008) and Egbebi and Bademosi (2011), which is due to the fact that this flour has as main component the starch (Pacheco *et al.,* 2008) being, therefore, required the quantification of amylose and amylopectin. The flour obtained in this variety at 77 DAF is, apparently, an alternative

for an eventual use as raw material in production of food rich in carbohydrates or as a flour to enrich food products.

Conclusions

- The plantain flour from the Pelipita variety presented the lowest humidity values (< 10%), which facilitates its storage for long periods and its use in the food industry.
- Contents of fat, fiber and ashes on flours of both varieties were suitable for its use in industrial processes.
- The developmental stage of the fruit affected ($P \leq 0.05$) the contents of protein, raw fiber and ash but, not the percentages of fat and humidity. .
- Papocho's plantain flour presented the highest protein content when harvested 70 days after flower anthesis; while the flour for the Pelipita variety showed the highest percentages of carbohydrate (85.86%) when the harvesting was done at 77 days after anthesis.

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