



Physicochemical and Nutritional Values of Some Recipes Made of Bananas and Plantains consumed in the East Region of Cameroon

^{1&2*}NGOH Newilah GB, ¹MANJIA Ngoungoure SU,
²TEMBE Tembe J, ²NKOUANDOU M, ²NGOMBI Ngombi E,
¹KENDINE Vepowo C, ¹KUIATE JR

¹University of Dschang, Department of Biochemistry – 67 Dschang, Cameroon.
²Centre Africain de Recherches sur Bananiers et Plantains, Postharvest Technology Laboratory – 832 Douala, Cameroon.

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*Corresponding Author

Ngoh Newilah Gerard Bertin

E-mail: gerard.ngoh@univ-dschang.org, gngoh@gmail.com

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ABSTRACT

BACKGROUND. In order to evaluate and improve people's nutritional status, it is essential to know the nutrient contents of food in general, and that of processed food in particular since the treatments the latter undergo are likely to modify their nutritional characteristics. This study aimed to contribute to the assessment of the nutritional composition of dishes made of bananas or plantains consumed in the East region of Cameroon, thereby providing additional data suitable for improving the nutritional status of populations of this region in particular and that of Cameroon in general. **METHODS.** Consumption and culinary surveys were conducted with 88 households in Bertoua, Dimako and Abong-mbang through a participatory approach. Following these surveys, samples of dishes were collected for macronutrients (carbohydrates, lipids and proteins), ash and dry matter content analysis using AOAC recommended methods. Micronutrients were assessed using atomic absorption spectrophotometry, while simple chemical techniques were used for the determination of pH, total titratable acidity (TTA) and total soluble solids (TSS). **RESULTS.** People of the East region of Cameroon cook and eat dishes derived from either bananas or plantains. Recipes of the 10 most consumed dishes have been clearly described. pH, TSS, TTA of the dishes depends of the repining stage of plantains or banana use in the dishes preparation. Micronutrient analyses showed high amounts of mineral elements in various dishes. The high energy value of Koukoul, *Malaxé of plantain*, *Banana fritter* could be assumed to the lipids content of the dishes as a results of oil add while preparing the dishes. **CONCLUSIONS.** Recipes generally containing banana and other ingredients are usually balanced as it is the case of "Malaxé of plantain" (47.14% carbohydrates, 12.21% proteins and 32.25% lipids) which can cover the recommended daily food intake and contribute to the improvement of the nutritional status of Cameroonians.

INTRODUCTION

For a proper well-being, man must eat variety of foods deriving either from animals or plants which contain nutrients Tremolieres *et al.* (1984) necessary for physiological functions such as basal metabolism, physical activity, growth, lactation Dupin *et al.* (1996). Malnutrition defined as an imbalance between food intake and food expenditure is responsible for many socioeconomic problems to human beings (The World Bank, 2006). In Cameroon, the loss of productivity due to inadequate intakes of nutrients between 2002 and 2011 was evaluated at 583 billion CFAF and about 33% of children less than 5 years suffer from chronic malnutrition (INS, 2012).

Plantains and cooking bananas are staple food crops for approximately 70 million of central and occidental African inhabitants (Tchango Tchango and Ngalani, 1998). In Cameroon, plantains are consumed fresh as desserts at ripen stages for some cultivars or processed (into boiled pulps, fried pulps, dried pulps, pounded pulps, etc.) either at green or ripen stages for almost all cultivars. They are generally eaten cooked or boiled green/unripe and eaten as a vegetable, fried when ripe or unripe to make fried-ripe-plantains or chips, baked when ripe or green, mashed, etc. (Ngoh Newilah *et al.*, 2005). Bananas and plantains constitute the third staple food crop after rice and cassava Dury *et al.* (2002). According to Chandler (1995), bananas are energy-rich foods (100g yielding 90 Kcal), and are important sources of minerals (potassium, calcium, magnesium, phosphorus) and vitamins (A, B6, C). In 2010, bananas and plantains production in Cameroon was estimated at 1.33 and 3.18 millions of tons respectively, with the East Region producing 863.626 tons of plantain alone (AGRI-STAT, 2012).

In spite of the aforementioned characteristics, Cameroonians still suffer from malnutrition, especially the inhabitants of the East Region. Inge *et al.* (2004) and Trèche (1989) stressed out the importance of consuming food capable of fulfilling both energy and nutrients requirements with respect to the physiological status and the eating habits of an individual. Before consumption, food undergoes various treatments which may affect its nutrients content. Thus, the nutritional problems of the population may be due to the methods of preparation of bananas and plantains. Cooking often leads to physicochemical and nutritional modification of food (Kumar and Aalbersberg, 2006), and recipes are often made of various ingredients which contribute together to the food quality.

The objective of this work was to contribute to the assessment of the nutritional value of dishes made from either bananas or plantains produced and consumed in the East region of Cameroon, hence providing additional data suitable for improving the nutritional status of populations of this region in particular and that of Cameroon as a whole.

MATERIALS AND METHODS

Study area

This study was carried out from November 19th 2014 to January 13th 2015 in three localities of the East region of Cameroon, namely Bertoua, Dimako and Abong-mbang.

Surveys and sampling

A consumption survey was conducted with 88 households in the cities of *Bertoua*, *Dimako* and *Abong-mbang* to identify dishes made from either banana or plantain consumed by these populations. During the household visits, careful observations and measurements were made to identify the type and quantity of ingredients as well as the chronology of operations used to prepare the dishes and the time of preparation. Each prepared meal collected from either 2 or 3 families, was cooled at room temperature, wrapped in aluminium foil, put in a polyethylene bag and packed in a plastic jar. The samples were first frozen in a home freezer and packed in an icebox, then transported to a laboratory of the African Research Center on Bananas and Plantains (CARBAP) and stored at -20°C prior to analyses.

Physicochemical and nutritional analyses

Physicochemical analysis

Apart from the dry matter content which was done directly on the fresh sample, the other analyses were performed on dry powders obtained by blending the lyophilized samples.

Dry matter content was assessed directly on the fresh sample in an oven at 105°C until constant weight. Ash content was done by incineration in a muffle furnace at 550°C for 2 hours. The pH was measured with a pH meter. Total titratable acidity (TTA) was assessed manually by titration with 0.1 N Sodium Hydroxide until the endpoint of the reaction characterized by the change in color of the phenolphthalein indicator (from colorless to pink/red). Results were expressed as milliequivalent per litre sample in terms of malic acid which is the predominant acid present in bananas and plantains according to Josylin (1970). Total soluble solids (TSS) were performed using a Hand-held refractometer which measures TSS as °Brix in 0.1% graduations.

Nutritional analysis

Proteins were analyzed by total nitrogen determination using Kjeldahl method and the conversion factor of 6.25; meanwhile total lipids were determined by extraction in a Soxhlet apparatus for 12 hours using hexane as solvent (Bourelly, 1982). Carbohydrates were obtained by the difference method (AOAC, 1980). The energy values of the dishes were calculated using energy conversion factors according to Atwater and Bryant (1990). The minerals (Calcium, Magnesium, Sodium, Potassium, Iron, Copper, Zinc, Manganese and Iodine) were determined using an

atomic absorption spectrophotometer while phosphorus was determined by colorimetry Pauwels *et al.* (1992).

Statistical analysis

Data on the composition of banana and plantain derived foods were evaluated by means of one-way analysis of variance using statistical package SPSS 16.0. Differences between samples were tested according to Duncan Waller test and considered to be significant when $p < 0.05$.

RESULTS AND DISCUSSION

Description of the recipes

The survey revealed 10 most consumed recipes in the Eastern region of Cameroon: "mashed plantain" or *Ndengué*, "Pounded plantain" or *Ntuba*, "Plantain gruel" or *Boulesoual*, "Plantain paste with unrefined palm oil" or "*Koukoul*", "Tisane de plantain", "Boiled plantain", "*Malaxé* of plantain", "Fritters of ripe banana paste", "Fried plantains" and "Roasted plantain". Table 1 displays their description with approximate quantity of ingredients for preparation.

Culinary preparation of the recipes

Plantain gruel "*Boulesoual*"

- Peel the ripe plantains and slice the pulps in small pieces;
- Put the sliced pulps in a pot, add water, pepper, and citronella leaves;
- Boil the mixture for about 23 min;
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- After the preparation, if there is still water, remove it and keep aside;
- Use a pestle to completely grind the cooked pulps;
- After grinding the pulps add the kept water to obtain a mushy drinkable substance.

According to the local consideration, pepper is used to avoid stomach pain because of the sugar level of plantain used for the preparation.

Mashed plantain or "*Ndengué*"

- Peel both the unripe and perfectly ripe plantains and slice them into small pieces;
- Add water and cook for about 30 min;
- After the preparation, if there is still water, removed it and keep aside;
- Use a pestle to partially grind the cooked pulps;
- Add the water to obtain the purée.

Mashed plantain is used as a starchy complement and is eaten with some mocal sauces as well as fried beans. According to local assertion the ground plantain facilitates digestion and avoids stomach pain, so "*Ndengué*" can be suitable for infants, the elderly and people suffering from stomach pain.

"*Malaxé* of plantain"

- Peel the plantains and slice the pulps into small pieces;
- Wash the sliced pulps and put them in a clean pot;
- Add the slices, tomatoes and onions;
- Grind ginger, garlic, white pepper, black pepper and add to the mixture;
- Add salt, water and palm oil;
- Cook for about 26 min.

Table 1: Recipes composition

Local name of dishes	Ingredients	Banana or plantain stage of ripeness	Variety of banana or plantain used in the recipes	
"Boulesoual"	<ul style="list-style-type: none"> ✓ 730g of perfectly ripe plantain pulp ✓ 935mL of water ✓ 1 pepper ✓ Citronella leaves to perfume 	Stage7 or stage 8	<i>Mbouroukou</i> n°2 locally called "Gwack" is more suitable for the recipe	 <p>a. "Boulesoual"</p>
"Ndengué"	<ul style="list-style-type: none"> ✓ 1207g of unripe plantain pulp ✓ 383g of perfectly ripe plantain pulp ✓ 1500ml of water 	Stage 1 Stage 8 or stage 9	All plantain varieties can be suitable for these recipes	 <p>b. "Ndengué"</p>
"Malaxé of plantain"	<ul style="list-style-type: none"> ✓ 832.75g of unripe plantain pulp ✓ 155g of dried fish ✓ 165ml of unrefined palm oil ✓ 303.5g of Tomato ✓ 54.24g of Onion ✓ 15g of garlic ✓ 18.75g of Salt ✓ 5.62g of Pepper ✓ 20g of Ginger ✓ 1.75g of white pepper ✓ 8.06g of Cube ✓ 762.5ml of water 	Stage 1	All "French" and "faux cornes" plantain types are suitable	 <p>c. "Malaxé of plantain"</p>
"Koukoul"	<ul style="list-style-type: none"> ✓ 850g of ripe plantain pulp ✓ 150ml of unrefined palm oil ✓ 6.66g of salt ✓ 475ml of water 	Stage 4 or stage 5	All plantains varieties can be suitable for these recipes	 <p>d. "Koukoul"</p>

"Tisane de plantain"	<ul style="list-style-type: none"> ✓ 566g of unripe plantain pulp ✓ 15g of bitter eggplant ✓ 5g of pepper ✓ 917ml of water ✓ Citronella leaves 	Stage 1	French type plantain is suitable for these recipes	 <p>e. "Tisane de plantain"</p>
"Roasted plantain"	✓ Plantain	Stage 1 to stage 5	"French" type, "faux cornes" type and "bâtard" type of plantain are suitable	 <p>f. "Roasted plantain"</p>
"Fried plantain"	<ul style="list-style-type: none"> ✓ 1125g of ripe plantain pulp ✓ 750ml of refined or unrefined palm oil 	Stage 5 and stage 6	All plantains varieties can be suitable for these recipes	 <p>g. "Fried plantain"</p>
"Ntuba"	<ul style="list-style-type: none"> ✓ 1700g of unripe plantain pulp ✓ 312.5g of ripe plantain pulp ✓ 960ml of water 	Stage1 Stage 4 and stage 5	A Plantain variety called "Elat" is more suitable	 <p>h. "Ntuba"</p>
"Boiled plantain"	<ul style="list-style-type: none"> ✓ 1250g unripe plantain pulp or ✓ 1300g of semi ripe plantain pulp ✓ 1875g of ripe plantain pulp ✓ 767ml of water 	Stage 1 Stage 3 and stage 4 Stage 5 and stage 6	All varieties of plantain	 <p>i. "Boiled plantain"</p>
"Banana fritters"	<ul style="list-style-type: none"> ✓ 2048g of perfectly ripe banana pulp ✓ 533.33g of wheat flour ✓ 1086 g of corn flour ✓ 20.66g of baking powder ✓ 3.33g of salt ✓ 150ml of water 	Stage 7 or stage 8	All banana variety are suitable for the recipes	 <p>j. "Banana fritters"</p>

Plantain paste with unrefined palm oil or "Koukoul"

- Peel the plantains and slice the pulps to ease cooking;
- Add salt and water and cook till water evaporates completely;
- With a pestle grind the cooked pulps;
- Add unrefined palm oil in the paste and mix gently;

Serve or roll up and cut the paste with a knife before serving.

"Tisane de plantain"

- Peel the unripe plantains and scrap the tiny membrane covering the pulp;
- Cut the pulps in two pieces and put them in a pot;
- Add eggplant, citronella leaves, pepper and water;
- Cook the mixture for about 28 min and serve hot.

According to local assertion this recipe stimulates the production of breast milk.

"Roasted plantain"

- Peel the plantains and make cross incisions on the pulps to facilitate the roasting;
- Roast the pulps on a wire-netting using charcoal (as heat source);
- Turn the pulps from time to time to let the other sides be in contact with heat, until the pulps become soft.

The roasted plantain is eaten with palm oil, roasted plum, meat (chicken, pork, beef) and sauces.

"Fried plantain"

- Peel the ripe plantains and slice the pulps transversally in pieces of about 1.5 cm;
- Fry the pulp in hot oil (refined and unrefined) for about 7 min;
- Use a skimmer to remove the fried plantains from the frying oil and put them in a colander to let oil go out.

Fried plantain can be eaten with fried eggs, fried fish, tomato sauce, fried vegetables, and other roasted meats.

Pounded plantain or "Ntuba"

- Peel both the unripe and ripe plantains, cut the pulp into two pieces;
- Wash the pieces and put them in a pot;
- Add water and boil for about 35 min;

- Remove the boiled pulps, chill them first or pound them directly when the pulps are still hot in a mortar using a pestle;
- Pound vigorously to obtain a homogeneous paste;
- Wrap up the paste in banana leaves or use a thread to cut the paste and serve it.

"Ntuba" is eaten with groundnut soup, tomato sauce, fried vegetables, etc.

"Boiled plantain"

- Peel the plantains and scrap the tiny membrane covering the pulps;
- Wash the pulps and cut them into two pieces if the plantain pulps are big;
- Put the pulps in a clean pot, add water and boil for about 26 min depending on the fruit's grade (for a rapid water diffusion, water can first be boiled before introducing the plantain pulps).

Boiled plantain is eaten with sauces (tomato or groundnut), fried vegetables and beans.

"Banana fritter"

- Peel the perfectly ripe bananas and pound the pulps;
- Add wheat flour, corn flour, baking powder and mix vigorously to obtain a homogeneous paste;
- Add a bit of water to soften the paste;
- Put the paste in a container, close it and allow to rest for 15 to 30 min;
- Heat the palm oil (refined or unrefined) that will be used for frying;
- Cut the paste into small pieces and put them in the hot oil;
- Fry for about 10 min turning it over frequently to let the other sides get fried too.

Banana fritter can be eaten with fried fish, fried beans.

Physicochemical characteristics

Table 2 presents the physicochemical characteristics of the 10 most consumed dishes made from either banana or plantain by the population of the East region of Cameroon. The dry matter of the different dishes ranged from 15.85% DW ("Boulesoual") to 63.33% DW ("Banana fritters") and their moisture content were respectively 36.67 % FW and 84.15% FW. The ash content of the different dishes ranged from 4.75% DW ("Boulesoual") to 15.42 % DW ("Fried plantain"). The TSS varied from 23.20 g/l ("Tisane de plantain") to 54.70 g/l ("Boulesoual"). TTA ranged from 2062.50 mEq/100g DW ("Malaxé of plantain") to 4875.00 mEq/100 g DW ("Boulesoual") and the pH varied from 4.90 to 6.03.

Table 1 : Physicochemical characteristics of the dishes

Parameters	Ash(DW)	%DW	pH	(TSS) (g/l)	TTA (meq/100g FW)	Water content (g/100g FW)
Dishes						
“ <i>Ndengué</i> ”	6.00 ± 1.03 ^{cd}	23.17 ± 1.19 ^f	5.50 ± 0.20 ^b	33.70 ± 8.99 ^b	2625.00 ± 433.01 ^{cd}	76.83 ± 1.19 ^b
“ <i>Koukouf</i> ”	5.93 ± 1.61 ^{cd}	40.60 ± 0.80 ^d	4.93 ± 0.21 ^d	35.20 ± 17.66 ^{ab}	4312.50 ± 718.07 ^{ab}	59.40 ± 0.80 ^d
“ <i>Boulesoual</i> ”	4.75 ± 0.27 ^d	15.85 ± 0.99 ^g	5.06 ± 0.18 ^{cd}	54.70 ± 15.51 ^a	4875.00 ± 37.00 ^a	84.15 ± 0.99 ^a
“ <i>Malaxé of plantain</i> ”	8.41 ± 1.12 ^b	33.45 ± 3.73 ^e	6.03 ± 0.10 ^a	26.20 ± 3.46 ^b	2062.50 ± 37.00 ^d	66.55 ± 3.73 ^c
“ <i>Ntuba</i> ”	7.38 ± 0.52 ^{bc}	37.24 ± 2.66 ^{de}	5.01 ± 0.15 ^d	27.70 ± 3.00 ^b	3562.50 ± 37.00 ^{bc}	62.76 ± 2.66 ^{cd}
“ <i>Boiled Plantain</i> ”	5.78 ± 0.22 ^{cd}	35.37 ± 1.12 ^{de}	4.99 ± 0.13 ^d	32.20 ± 6.00 ^b	4125.00 ± 433.01 ^{ab}	64.63 ± 1.12 ^{cd}
“ <i>Fried Plantain</i> ”	15.42 ± 1.39 ^a	53.17 ± 5.16 ^b	4.90 ± 0.14 ^d	35.20 ± 8.48 ^{ab}	4687.50 ± 943.72 ^a	46.83 ± 5.16 ^f
“ <i>Banana Fritter</i> ”	4.85 ± 0.31 ^d	63.33 ± 2.88 ^a	5.36 ± 0.75 ^{bc}	25.20 ± 6.92 ^b	2250.00 ± 0.00 ^d	36.67 ± 2.88 ^g
“ <i>Tisane de Plantain</i> ”	6.11 ± 0.80 ^{cd}	24.46 ± 2.17 ^f	5.59 ± 0.18 ^b	23.20 ± 6.00 ^b	2250.00 ± 0.00 ^d	75.54 ± 2.17 ^b
“ <i>Roasted Plantain</i> ”	5.81 ± 1.35 ^{cd}	47.04 ± 4.57 ^c	4.91 ± 0.03 ^d	32.20 ± 3.00 ^b	4125.00 ± 37.00 ^{ab}	52.96 ± 4.57 ^e

Mean values in the same column with different superscript letters are significantly different ($P < 0.05$).

Mineral content of the recipes

Macro elements contents of the recipes

The macro elements content of the 10 most consumed dishes made from either banana or plantain by the population of the East Region of Cameroon are presented in table 3. Potassium levels were comprised between 257.94 mg/100g DW (“*Fried plantain*”) and 142.86 mg/100g DW (“*Banana fritter*”). Phosphorus

contents ranged from 142.70 mg/100g DW (“*Banana fritter*”) to 96.43 mg/100g DW (“*Boulesoual*”), meanwhile Calcium contents ranged from 22.93 mg/100 g DW (“*Ntuba*”) to 10.42 mg/100g DW (“*Boiled plantain*”).

Magnesium levels were comprised between 13.49 mg/100g DW (“*Boulesoual*”) and 8.82 mg/100 g DW (“*Malaxé of plantain*”). Sodium contents of the dishes varied from 4.05mg/100 g DW (“*Boulesoual*”) to 0.89mg/100g DW (“*Fried plantain*”).

Table 2 : Macro elements contents of the dishes expressed in g/100 DW

Minerals	Ca	K	Mg	P	Na
Dishes					
“ <i>Ndengué</i> ”	20.56 ± 4.18 ^a	230.66 ± 55.1 ^{ab}	9.28 ± 1.05 ^b	127.74 ± 22.46 ^a	2.90 ± 0.79 ^{abc}
“ <i>Koukouf</i> ”	22.31 ± 3.45 ^a	240.09 ± 90.63 ^{ab}	10.14 ± 0.23 ^b	121.92 ± 9.12 ^a	2.63 ± 0.72 ^{abc}
“ <i>Boulesoual</i> ”	21.50 ± 1.51 ^a	223.75 ± 13.28 ^{ab}	13.49 ± 0.35 ^a	96.43 ± 0.00 ^a	4.05 ± 0.85 ^a
“ <i>Malaxé of plantain</i> ”	17.03 ± 3.69 ^a	205.31 ± 33.57 ^{ab}	8.82 ± 0.97 ^b	122.19 ± 54.61 ^a	2.36 ± 0.65 ^{abc}
“ <i>Ntuba</i> ”	22.93 ± 1.52 ^a	235.85 ± 21.46 ^{ab}	9.07 ± 0.29 ^b	105.48 ± 21.87 ^a	1.57 ± 0.95 ^c
“ <i>Boiled Plantain</i> ”	10.42 ± 2.08 ^b	223.65 ± 49.86 ^{ab}	9.87 ± 0.56 ^b	104.89 ± 12.72 ^a	2.43 ± 1.00 ^{abc}
“ <i>Fried Plantain</i> ”	17.65 ± 4.68 ^a	257.94 ± 13.92 ^a	9.44 ± 1.05 ^b	102.57 ± 7.47 ^a	0.89 ± 1.05 ^c
“ <i>Banana Fritter</i> ”	17.82 ± 5.65 ^a	142.86 ± 57.59 ^b	9.63 ± 0.82 ^b	142.70 ± 26.55 ^a	3.77 ± 2.00 ^{ab}
“ <i>Tisane De Plantain</i> ”	19.67 ± 1.70 ^a	246.67 ± 2.88 ^a	9.16 ± 0.43 ^b	98.25 ± 29.77 ^a	2.02 ± 0.14 ^{abc}
“ <i>Roasted Plantain</i> ”	10.66 ± 0.58 ^b	242.63 ± 12.36 ^a	9.77 ± 0.01 ^b	142.27 ± 29.27 ^a	1.89 ± 1.69 ^{bc}

Mean values in the same column with different superscript letters are significantly different ($P < 0.05$).

Microelements contents of the recipes

Table 4 highlights the micro elements contents of the 10 most consumed dishes made from banana or plantain by the population of the East region of Cameroon. Iron contents ranged from 10.86 mg/100g DW (“Tisane de plantain”) to 4.51 mg/100g DW (“Roasted plantain”), while Zinc contents varied from 2.50 mg/100g DW (“Koukoul”) to 1.05mg/100g DW

(“Roasted plantain”). Copper levels were low and comprised between 0.19 mg/100g DW (“Tisane de plantain”, “fried plantain”) and 0.10 mg/100g DW (“Ndengué”, “Boulesoual”). Manganese contents varied from 0.06 mg/100g DW (“Roasted Plantain”) to 0.03 mg/100g DW (“Boulesoual”, “banana fritter”). Iodine contents ranged from 0.49 mg/100g DW (“Boiled plantain”) to 0.18 mg/100g DW (“Fried plantain”).

Table 3 : Micro elements contents of the dishes expressed in mg/100g DW

Mineral	Fe	Zn	Cu	Mn	I
Dishes					
“Ndengué”	6.32 ± 0.31 ^{cd}	2.31 ± 0.77 ^{ab}	0.10 ± 0.02 ^c	0.04 ± 0.01 ^a	0.43 ± 0.27 ^a
“Koukoul”	9.26 ± 0.99 ^{ab}	2.50 ± 0.66 ^a	0.12 ± 0.01 ^{abc}	0.04 ± 0.01 ^a	0.42 ± 0.21 ^a
“Boulesoual”	8.34 ± 0.37 ^{bc}	1.75 ± 0.31 ^{ab}	0.10 ± 0.01 ^c	0.03 ± 0.01 ^a	0.33 ± 0.07 ^a
“Malaxé of plantain”	6.97 ± 1.48 ^c	1.84 ± 0.77 ^{ab}	0.16 ± 0.04 ^{abc}	0.05 ± 0.01 ^a	0.47 ± 0.13 ^a
“Ntuba”	6.36 ± 2.09 ^{cd}	1.64 ± 0.74 ^{ab}	0.13 ± 0.06 ^{abc}	0.04 ± 0.01 ^a	0.31 ± 0.19 ^a
“Boiled Plantain”	6.74 ± 0.61 ^c	2.30 ± 0.37 ^{ab}	0.12 ± 0.04 ^{bc}	0.05 ± 0.01 ^a	0.49 ± 0.21 ^a
“Fried Plantain”	8.35 ± 0.94 ^{bc}	2.46 ± 0.70 ^{ab}	0.19 ± 0.02 ^a	0.04 ± 0.01 ^a	0.18 ± 0.20 ^a
“Banana Fritter”	6.45 ± 0.50 ^{cd}	2.09 ± 0.69 ^{ab}	0.12 ± 0.01 ^{abc}	0.03 ± 0.02 ^a	0.34 ± 0.06 ^a
“Tisane De Plantain”	10.86 ± 1.02 ^a	2.21 ± 0.50 ^{ab}	0.19 ± 0.04 ^{ab}	0.05 ± 0.02 ^a	0.40 ± 0.02 ^a
“Roasted Plantain”	4.51 ± 0.48 ^d	1.05 ± 0.27 ^b	0.18 ± 0.01 ^{ab}	0.06 ± 0.01 ^a	0.38 ± 0.33 ^a

Mean values in the same column with different superscript letters are significantly different (P < 0.05).

Macronutrients contents and energy values of the recipes

The macronutrients and energy contents of the 10 most consumed dishes made from banana or plantain by the population of the East region of Cameroon are presented in Table 5. The lipids content of the dishes

varied from 12 to 32 g/100g DW respectively for “Roasted plantain” and “Malaxé of plantain”. These two recipes also have the minimal and maximal values for protein and carbohydrate contents respectively (0.50 - 12.21g/100g DW and 47 – 81g/100g DW). The energy values of the dishes were less than 530 Kcal/100g DW.

Table 4 : Macronutrients and energy contents of the recipes

Parameters	Lipids	Carbohydrates	Proteins	Energy value
Dishes	(g/100gDW)	(g/100gDW)	(g/100gDW)	(Kcal/100gDW)
“Ndengué”	13.35 ± 1.02 ^c	78.74±1.11 ^{ab}	1.91 ± 0.58 ^{def}	442.70 ± 5.43 ^c
“Koukouli”	30.65 ± 3.67 ^a	60.30±3.00 ^d	3.13 ± 0.49 ^{bcd}	529.52 ± 21.61 ^a
“Boulesoual”	14.16 ±1.38 ^c	78.42±1.55 ^{ab}	2.67±0.77 ^{cde}	451.80 ± 7.51 ^c
“Malaxé of plantain”	32.25 ± 4.20 ^a	47.14±5.78 ^e	12.21 ± 1.74 ^a	527.63 ± 18.59 ^a
“Ntuba”	13.16 ± 0.49 ^c	75.26±0.93 ^b	4.20 ± 0.42 ^b	436.28 ± 3.92 ^c
“Boiled Plantain”	13.00 ± 0.47 ^c	77.68±0.61 ^{ab}	3.55 ± 0.50 ^{bc}	441.86 ± 3.18 ^c
“Fried Plantain”	20.11 ± 1.63 ^b	63.20±1.69 ^{cd}	1.27 ± 0.39 ^{ef}	438.90 ± 11.29 ^c
“Banana Fritter”	23.96 ± 1.54 ^b	66.64 ± 1.36 ^c	4.55 ± 0.18 ^b	500.38 ± 8.04 ^b
“Tisane De Plantain”	14.88 ± 0.29 ^c	77.49 ±0.84 ^{ab}	1.52 ± 0.22 ^{ef}	449.99 ± 4.27 ^c
“Roasted Plantain”	12.50 ± 0.52 ^c	81.18 ± 2.46 ^a	0.50 ± 0.03 ^f	439.26 ± 5.02 ^c

Mean values in the same column with different superscript letters are significantly different (P < 0.05).

DISCUSSION

Water and ash content

The water content of the various dishes varied from one recipe to the other. “Boulesoual” and “Banana fritter” presented the maximum and minimum contents respectively. In fact the quantity of water used when preparing a recipe influences its water content. We then understand why “Boulesoual” which was prepared with about 1L of water for 700g of plantain pulp presented the highest water content. The result obtained in this case (66.54%) is less than the 83% obtained by Kana Sop *et al.* (2008).

The water and ash content presented a negative correlation ($r=-0.383$, $p<0.021$), this justifies the smallest ash content (4% DW) obtained by “Boulesoual”. On the other hand, “Fried plantain” presented the highest content (15.42% DW). In fact boiling usually leads to a significant loss of minerals due to their diffusion from food to boiling water (Cuq, 1992). Moreover the highest ash content of “Fried plantain” can result to the fact that frying favors minerals retention due to the migration of water particles from food to oil (Kawashima and Valente-Soares, 2003).

Total titratable acidity (TTA) and pH

TTA and pH are negatively correlated ($r= -0,829$, $p <0,001$), thus an increase in pH implies a decrease in

TTA in either banana or plantain. This therefore explains why “Malaxé of plantain” presented a low TTA in contrast with “Boulesoual” presenting a high TTA. The plantains used for the preparation of “Malaxé of plantain” were in stage 1 of ripeness while those used in the preparation of “Boulesoual” were in stage 6 to 8 of ripeness. It has been shown that acid levels present in bananas and plantains increase during ripening (Dadzie and Orchard, 1997). This is due to increase in acids content of the pulp particularly citric, malic and oxaloacetic acids Satyan *et al.* (1984). These results are in line with those of Kouamé *et al.* (2010) and Ngho Newilah *et al.* (2011).

Total soluble solids (TSS)

The TSS gives information on banana and plantain maturity stage used in the recipes. A negative correlation was observed between the TSS and TTA rather than the pH. Generally the TSS increases with fruit ripening ((Dadzie and Orchard, 1997), Ngho Newilah *et al.*(2011). “Tisane de plantain” prepared with stage 1 plantain has a lower TSS while “Boulesoual” prepared with stage 6 to 8 plantain has a high TSS. This increase is the after-effect of metabolic processes occurring in banana fruits such as starch hydrolysis and accumulation of simples sugars such as glucose and fructose (Palmer, 1971) responsible for the sweetening of ripe fruit. These results are similar to those observed by Ngho Newilah *et al.* (2011) during

the ripening of some plantain cultivars and *Musa* hybrids grown in Cameroon

Macronutrients and energy contents

High proteins and lipids contents were observed in “*Malaxé* of plantain” while “roasted plantain” presented the lowest values. “Roasted plantain” is prepared without additional ingredient, while “*Malaxé* of plantain” is prepared with many ingredients (Table 1). The fish added in “*Malaxé* of plantain” helps to increase the protein level. The protein content of “*Malaxé* of plantain” (12.21g/100g DW) is comparable to the reference values (15g/100g DW) while the carbohydrates content of “Roasted plantain” is greater than reference values 67 g/100 g DW Herberg *et al.*(1985).

“*Koukou*” presented the highest energy content (529.52 Kcal) while “*Ntuba*” presented the lowest energy content (436.28 Kcal). The oil used in the “*Koukou*” preparation can explain this difference because the energy bound by 1g of lipids represents twice the energy bound by 1g of carbohydrates (Atwater and Bryant, 1899). Despite its energy content “*Koukou*” is poor in protein (3.13%) and is usually eaten alone creating an imbalance in the daily food intake. In this context “*Ntuba*” which is consumed with sauces may be balanced if it is consumed with a protein-rich sauce. L’Agence Nationale de Sécurité Sanitaire de l’Alimentation et de l’Environnement du Travail (ANSES) recommends that the contribution of each macronutrient for a balanced food intake should be 45 to 50% for carbohydrates, 15% for proteins, 35 to 40 % for lipids (ANSES, 2011). With its macronutrients contents 47.14% carbohydrates, 12.21% proteins and 32.25% lipids “*Malaxé* of plantain” can be classified as a balanced food, thus its consumption could help to improve the nutritional status of the population.

Micronutrients

Macro elements content

Potassium contents of all the analyzed dishes were low compared to those obtained by Kana Sop *et al.* (2008) in some household dishes consumed in Douala (Littoral region of Cameroon). Sodium contents of the dishes were low compared to those of some dishes consumed by some natives of Bassa plateau in Nigeria Madukorsiri *et al.* (2009). Sodium together with potassium ensures acid-base equilibrium in the human body. Unlike sodium, potassium decreases blood pressure in people suffering from high blood pressure while its deficiency increases the blood pressure Potier de Courcy *et al.* (2003), thus “fried plantain” consumption should be encouraged to people suffering from high blood pressure. Calcium contents of the analyzed dishes were higher compared to those reported by Sangita Sharma *et al.* (2007) in “Pounded plantain” (5.4mg/100g DW). Calcium contributes to bones and teeth formation and maintains them in good health (Wardlaw and Smith, 2007). “*Ntuba*” consumption should be encouraged for children and

people suffering from osteoporosis. Phosphorus and magnesium contents of the dishes were low compared to those obtained by Kana Sop *et al.* (2008) in some households consumed in Douala (Littoral Region Cameroon). Magnesium is the constituent of bones and teeth, and is a cofactor of many enzymes Murray *et al.* (2000).

Micro elements content

The iron contents of the dishes were highest compared to those reported by Ponka *et al.* (2005). Iron deficiency is responsible for anemia (Passeport santé, 2015), thus the consumption of “Tisane de plantain” should be encouraged to people who are more exposed to iron deficiencies (children under 5 years and pregnant women). Zinc contents of the dishes were higher compared to those obtained by Honfo *et al.* (2008) in some foods made from banana or plantain consumed in Cameroon. Zinc is important in cell renewal, healing and immunity (Black, 2003). Copper contents were lower compared to those of some Cameroonians’ households consumed in Douala (Littoral region of Cameroon) reported by Kana Sop *et al.*, (2008). Copper is necessary in red blood cells formation and lymphocytes replication, thus it stimulates the immune system (Burke and Miller, 2006). Manganese contents of the analyzed dishes were low compared to those reported by Morakinyo *et al.* (2016) on some commonly consumed local foods in Nigeria. Manganese is the constituent of the enzyme super oxide dismutase (SOD), and thus prevents the damage caused by free radicals (Institute of Medicine, 2001).

CONCLUSION

The aim of this study was to describe and determine the nutritional and physicochemical characteristics of dishes made from banana or plantain consumed in the East Region of Cameroon. The following conclusions were drawn from the study: - Bananas and plantains represent the most abundant ingredient present in all the recipes - The maximal contents of K, P, Ca, Mg, Na, Fe, Zn, Cu Mn and I were found in “fried plantain”, “banana fritter”, “*Ntuba*”, “*Boulesoual*”, “*Boulesoual*” “Tisane de plantain”, “*Koukou*”, “Tisane de plantain”, “Roasted plantain” and “boiled plantain” respectively - The lipids content of the dishes varied from 12.5 to 32.25 g/100g DW respectively for “Roasted plantain” and “*Malaxé* of plantain”. These two recipes also have the minimal and maximal values for protein and carbohydrates contents respectively (0.50 - 12.21g/100g DW and 47 - 81g/100g DW) - The energy values of the dishes were less than 530 Kcal/100g DW. Recipes generally containing plantain and other ingredients are usually balanced as it is the case of “*Malaxé* of plantain” (47.14% carbohydrates, 12.21% proteins and 32.25% lipids) which can cover the recommended daily food intake. The data obtained in the framework of this study will contribute to the establishment of composition table of foods derived from bananas and plantains in Cameroon.

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