

Pancake Formulations Based on Plantain Flour (*Musa AAB*)

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Abstract: In order to contribute to the reduction of postharvest losses of bananas and plantains and to diversify uses of plantain in Cameroon, flours obtained from a local plantain cultivar (Big ebanga) were used for pancakes production. The results of physicochemical parameters of flours varied significantly ($P < 0.05$). In addition, the optimization of pancakes formulation enabled to retain three most appreciated preparations by consumers. Formulations were differently encoded, depending on their composition. They were further added to the conventional one based on wheat flour, also encoded, and the four products were submitted to a sensory evaluation gathering 72 tasters. They gave their valuation on the colour, taste, texture, aroma and the overall quality of each product following a hedonic scale of 9 points: 9 (I like extremely) to 1 (I don't like). Statistical analyses show that product 430 (made of 100% wheat flour) indicated an overall average appreciation of 7.29 while the product 136 (made of 100% of plantain flour) has an overall average rating of 6.76. After ANOVA, DUNCAN test showed no significant difference between the overall quality of product 430 and product 136. This study clearly indicates that plantain flour can be used for the preparation of pancakes that meet consumer's expectations.

Keywords: Plantain, Flour, Formulation, Pancakes

1. Introduction

Bananas are grown in more than 120 countries in the 5 continents [1] and over 10 million hectares [2]. Plantains (cooking type bananas) offer many type of uses. They are eaten mainly as a fresh fruit or as a cooked or fried vegetable but are also the subject of many transformations: chips, fries, donuts, mashed, jam, ketchup, alcohol, wine and beer. Plantain is the fourth agricultural product after rice, wheat and maize [2]. World production of plantain in 2013 is 29 517 842 tons, while Africa produces about 66.2% or 19 541 934 tons, and Cameroon produces up to 3 692 108 tons [3].

Plantain plays an important role in agriculture in most countries of central and western Africa, where it is a staple food and a major component of food security as well as an important source of income for different actors in the sector [4]. There are many traditional uses of plantain. They vary

according to the country and the dietary habits of consumers. Unripe banana flour has been studied as a functional ingredient, mainly as a source of unavailable carbohydrates, such as resistant starch, which is its more expressive component. Several studies on the unripe banana flour fermentation have shown its high fermentability and production of short-chain fatty acids (SCFA). SCFA have been associated to several benefic effects on intestinal health, as well as systemic effects on glucose and lipid metabolism [29].

The consumption of bakery products, especially bread, occupies a prominent place in the diet of people, even in non-wheat-producing countries. They are becoming increasingly dependent on wheat-producing nations, especially in economic crises, where wheat is becoming very expensive to import. In response to this situation, there is an increasing development of wheat flour substitution technologies using

flour from local food resources [5, 6]. In view of the alarming increase in consumption of wheat products in Africa, the Food and Agriculture Organization of the United Nations (FAO) launched in 1964 an extensive program for the upgrading of local cereals and root and tuber crops. Since then, much research under the aegis of FAO has shown that it is possible to partially replace wheat with local cereals and tubers such as sorghum, millet, maize and manioc in bread making and other new derivatives [7].

Although plantain represents an important source of nutrients for populations, the conditions for its distribution are essentially fresh. Postharvest losses of plantain in developing countries were estimated at almost 35% according to FAO [8]. These losses could be reduced with rational conservation and processing. In addition, the increasing importation of wheat flour used in bakery and pastry production propels the Postharvest Technology Laboratory of the African Research Centre on Bananas and Plantains (CARBAP) of Njombé (Littoral Region of Cameroon) to undertake testing of substitutions of this flour by plantain flour. These studies resulted in the development of multi-purpose flour. This scientific work was based on the necessity to prolong the life after the maturity of bananas or plantains, which are considered to be very perishable foods (it ripens between 5 to 9 days after the harvest according to the cultivars, if physiological maturity is reached).

Much of the production of bananas and plantains is consumed ripe in the raw state or as a cooked vegetable [9]. Only a very small part is transformed into conserved products. On the whole, conservable products do not contribute significantly to the diet of the millions of people who consume bananas around the world. However, in some countries and regions, processing and preservation help to "Welding" in times when food is scarce. Processing is one of the means available to preserve fruits. Nonetheless, very little is known about the proportion of processed fruits and the processing capacity of the different *Musa* groups. The present study aimed at promoting the use of flours based on plantain pulps for the manufacture of food products in Cameroon.

2. Material and Methods

2.1. Material

2.1.1. Biological Material

The plant material consisted of wheat flour and flour obtained from pulps of the local plantain variety namely *Big ebanga* and coded Beg (Figure 1). This cultivar was grown in a mini-collection of bananas, set up as part of the C 2D-PLANTAIN project. This variety was chosen because of its availability, its productivity and its high consumption in the Littoral Region of Cameroon. It has been widely disseminated since the 2000s by CARBAP in West and Central Africa (WCA). In addition, its production cycle is relatively short (10 months) and its dry matter content is relatively high compared to other local varieties; this making it possible to obtain a good quantity of flour.



Figure 1. A bunch of *Big ebanga*.

2.1.2. Technical Material

Table 1. Major equipment used during pancakes production in Postharvest Technology Laboratory.

Equipment	Uses / Roles
Gas oven	Drying plantain pulp
Handmade mill	Grinding of dried pulps
Frying pan Tefal Ø 28 cm	Cooking pancakes
Glass bowl	Pancake dough
Sieve in stainless steel 200µm	Sifting flour
Electric Brand Scale "Precisa Junior"	Weighing of ingredients
Gas Cooker	Heat Production
Stainless steel trays	Product overview for sensory tests
Disposable plastic dishes	Presentation of samples to tasters
Plastic glass	Rinse mouth and drink during sensory tests

2.1.3. Ingredients

Main Ingredients: Plantain flour, wheat flour, eggs, butter, semi-skimmed fresh milk. Additives of formulations: vanilla sugar, baking powder, salt, rum and refined palm oil.

2.2. Methods

2.2.1. Production of Plantain Flour

Undamaged unripe green fruits of *Big ebanga* from the mini collection of the C2D/PAR-PLANTAIN project (settled in September 2014 in Njombé: latitude 04° 35N, longitude 09° 39E and altitude 80m above sea level) were chosen and washed. They were then peeled and pulps cut into cubes of about 1 cm³, resulting in "cossettes" which underwent a

physical treatment (boiling water) for 3 to 5 minutes (to inactivate an enzyme called polyphenol oxidase (PPO) responsible for plantain pulp blackening when exposed to oxygen). The drying was carried out for 36 to 48 hours in a gas oven whose temperature was controlled between 45°C and 50°C. The dried “cossettes” were ground using an ordinary artisanal mill and the flour obtained was sieved using a 200 µm stainless steel sieve. Figure 2 shows the steps of flour production from banana pulps.

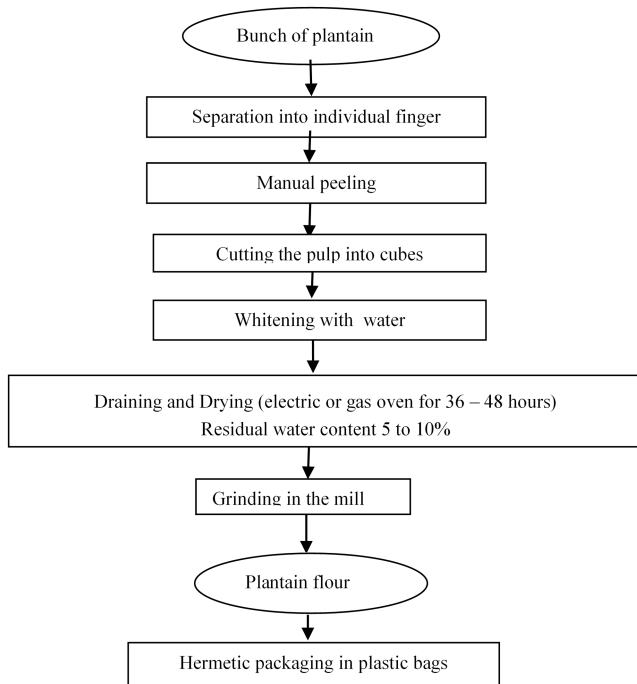


Figure 2. Major steps for plantain flour production, adapted from Tchango Tchango et al. [10].

2.2.2. Physicochemical Characterization of Flour

(i). Water Content

The water content (TE) was determined using a modified Association of Analytical Communities (AOAC) method [11] based on the measurement of the mass loss of the samples after baking at 105°C until complete removal of free water and volatile compounds. The vacuum cup was first cleaned, dried and weighed (M 0). A mass of 5 g of sample was weighed (M 1) and then placed in a Memmert oven, model 600 at 105°C for about 24 h. The cup was taken out of the oven and then cooled in a desiccator before being weighed (M 2) again. The results expressed as a percentage represent the mean ± standard deviation of three tests, determined according to formula (1).

$$TE = \frac{M1-M2}{M1-M0} \times 100 \quad (1)$$

(ii). Total Ash Content

The total ash content of the flours was determined according to the AOAC method [11]. It consisted of mineralizing 5 g of flour (contained in previously dried porcelain crucibles). The vacuum mineralization crucible was first cleaned, dried and weighed (M 0). The crucible

containing the wet product (5 g) was again weighed (M 1) and placed in an oven at 105°C for about 24 h. After drying, the crucible was removed from the oven and cooled in a desiccator (P₂O₅) before being weighed (M 2). Once weighed, the crucibles were introduced into the Vecstar furnace at 550°C, incinerated until it gets a white colour for about 48 hours, cooled in the desiccator and reweighed (M 3). The ash content was expressed as the mass of product remaining in the crucible after incineration in relation to its total dry matter.

$$\text{Ash content (\%)} = \frac{M3-M0}{M1-M0} \times 100 \quad (2)$$

(iii). Refractive Index or Total Soluble Solids Content

In fruits, there are a large number of water soluble compounds: sugars, acids, vitamin C, amino acids and pectins. These compounds constitute the soluble solids content of the fruit. The refractive index or total soluble solids content of the flour was determined as follows: Fifteen (15) g of flour were diluted in 45 ml of distilled water. The whole was homogenized using a Fisher brand® magnetic stirrer for about 5 min. After resting the assembly, a drop was placed on the prism of a hand refractometer (REF 113, Brix, 0-32 ATC) and the apparatus was pointed in the direction of a light source in order to read the refractive index (IR) which was used to determine the total soluble solids content (TSS). The recorded value (IR) was multiplied by three as the sample of flour extract was diluted in a triple volume of distilled water [12]. The soluble dry extract ratio (TESS) in “°Brix” was calculated according to formula (3).

$$\text{TSS (°Brix)} = 3 \text{ IR} - 0.8 \quad (3)$$

(iv). Determination of PH and Total Titratable Acidity

The pH indicates the acidity or alkalinity of a product, while total titratable acidity indicates the amount of acid present in this product. The electrode of the HANNA instrument pH meter was immersed in a beaker containing 20 ml of sample at ambient temperature (≈ 25°C). The result was read on the pH-meter screen. This operation was repeated thrice. Five (5) ml of each flour sample were placed in a 20 ml beaker, 5 ml of distilled water were added to the beaker, and then three (03) drops of phenolphthalein were added. The whole was titrated with 0.1 N sodium hydroxide solution (NaOH) until a persistent pink colour was obtained for about 10 seconds. This operation was done thrice for each sample. The total titratable acidity was determined according to formula (4).

$$\text{ATT (meq/100g)} = 1200 \times V_{\text{NaOH}} \quad (4)$$

2.2.3. Formulation of Pancakes Made From Plantain Flour

(i). Preliminary Tests

After crushing the “cossettes”, obtained flour was sieved using a 200 µm sieve. The first test was made with wheat flour only then with incorporation of 50% plantain flour and finally 100% plantain flour. Knowing that pancakes can be formulated using wheat flour, rice flour + durum wheat

flour, pea flour + buckwheat flour, several formulations using only plantain flour were investigated, this by varying three main ingredients: butter, eggs and semi-skimmed milk. These three variables have been used throughout our manipulations in order to allow us to retain an acceptable formulation.

(ii). Production of Pancakes

a. Experimental Design

According to Goupy & Creighton [13], the experimental design method is a technique of optimal organization of the experiments so as to obtain maximum information in a minimum of tests with the best precision possible. For the formulation of pancakes based on plantain flour, the methodology of surfaces responses was used. This approach was made by carrying out a composite central experimental design with three variables: quantity of butter (X1), quantity of semi-skimmed fresh milk (X2) and number of eggs (X3).

b. Determination of Real Variables

- (1) Butter: the bounds of this variable for the production of pancakes made from plantain flour were determined on the basis of preliminary tests: 25 to 100g for 125g of

plantain flour.

- (2) Semi-skimmed milk: the quantities of milk were determined through preliminary tests and ranged 250 and 450 ml for 125 g of plantain flour.
- (3) Eggs: the number of eggs used for the production of pancakes was also determined after preliminary tests and the number of eggs varied from 2 to 6 for a dough consisting of 125 g of plantain flour.

Table 2 and 3 were obtained using the Statgraphic version 5.0 mixing software. Table 2 summarizes the actual values corresponding to the levels of the variables studied. Table 3 shows the experimental matrix of the composite central plan with 3 variables.

Table 2. Coding factors for optimization of pancake formulations.

Command Variables	Coded levels
	$- \alpha (-1,73) - 1 \ 0 + 1 + \alpha (1,73)$
	Normal levels
Butter (X1)	25 40,82 62,5 84,2 100
Milk (X2)	250 292,2 350 407,80 450
Eggs (X3)	2 2,84 4 5,2 6

Table 3. Experimental plan for the preparation of plantain flour pancakes.

Experience	Experienced matrix			Plan of experimentation		
	X ₁	X ₂	X ₃	Butter (X ₁)	Milk (X ₂)	Eggs (X ₃)
1	0	0	0	62.5	350.0	4.0
2	0	0	0	62.5	350.0	4.0
3	-1	-1	-1	40.8	292.2	2.8
4	+1	-1	-1	84.2	292.2	2.8
5	-1	-1	+1	40.8	292.2	5.2
6	+1	-1	+1	84.2	292.2	5.2
7	-1	+1	-1	40.8	407.8	2.8
8	+1	+1	-1	84.2	407.8	2.8
9	-1	+1	+1	40.8	407.8	5.2
10	+1	+1	+1	84.2	407.8	5.2
11	$-\alpha$	0	0	25.0	350.0	4.0
12	$+\alpha$	0	0	100.0	350.0	4.0
13	0	0	$-\alpha$	62.5	350.0	2.0
14	0	0	$+\alpha$	62.5	350.0	6.0
15	0	$-\alpha$	0	62,5	250.0	4.0
16	0	$+\alpha$	0	62.5	450.0	4.0

c. Weighing and Measurement of Ingredients

Ingredients were weighed using a precision Junior electric scale with a sensitivity of 0.1 g and 0.001 g. The parameters 125 g of plantain flour, 15 g of caster sugar, a sachet of vanilla sugar and a pinch of salt have remained identical throughout our different formulations. Only the quantities of butter, eggs and semi-skimmed milk varied from one formulation to another.

d. Preparation of the Pancake Batter

The preparation of the dough requires the melting of the butter at low temperature. Once the melted butter is finished, it is introduced into the bowl and then, after a few minutes, the eggs are added. The sugar and salt are added after homogenizing the eggs and the butter. The introduction of plantain flour occurs once the sugar and salt have completely dissolved. The milk is introduced as the

dough is needed so that it can be very light at the end of the complete mixture. At the end, one to two tablespoons of Rum are introduced into our salad bowl and its contents are homogenized again with a whisk and then put to rest for about an hour.

e. Cooking

Cooking was done with a gas cooker. The temperature was adjusted so that cooking can be done under the same conditions (constant flame of the gas cooker). The pancake batter was introduced into the anti-stick frying pan using a table ladle. The side of the pancake was turned over after 2 to 2.5 minutes and then placed in a tray, packed a few minutes later with a table paper and put in another tray which will be available to tasters so that they can give their appreciation on organoleptic properties of manufactured pancakes. The cooking temperature of pancakes was between 75°C and 80°C.

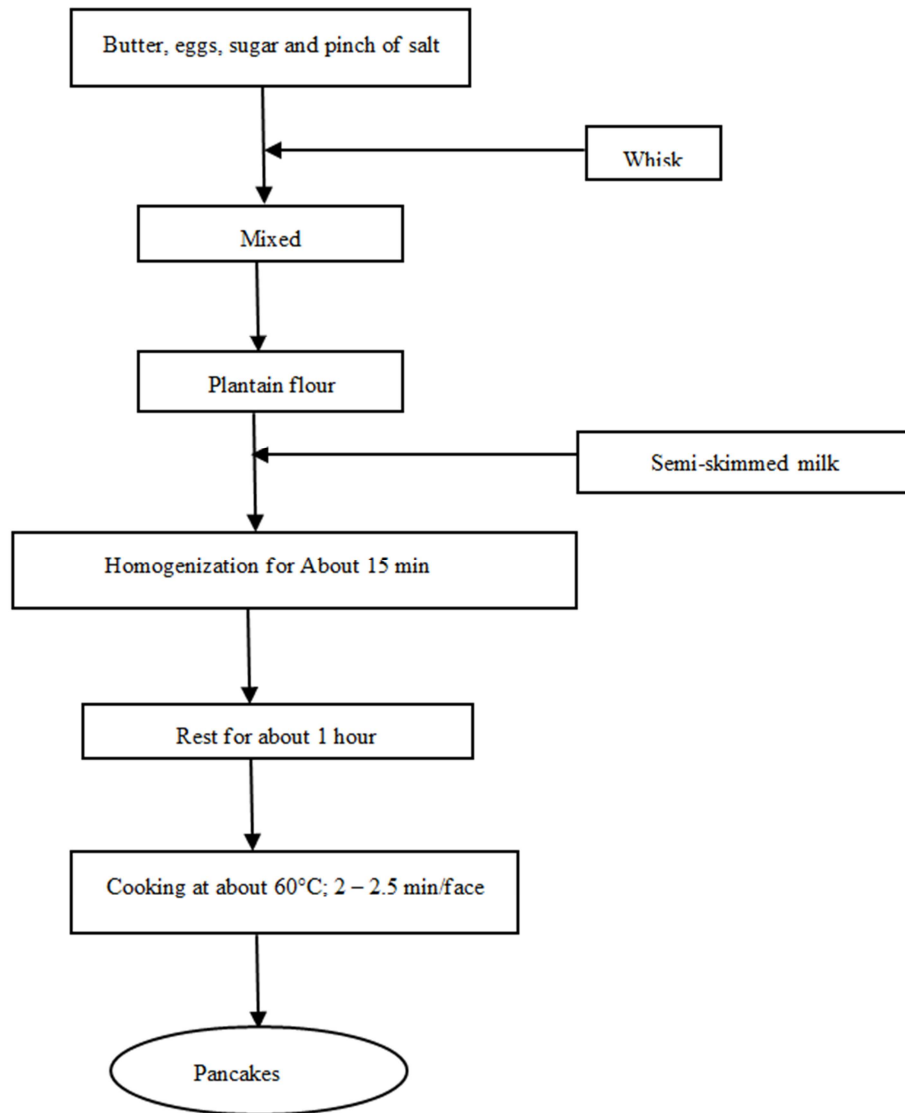


Figure 3. Steps of pancake production based on plantain flour.

2.2.4. Tasting Various Pancakes Formulated with Plantain Flour

The development of this test involved 5 to 15 people, familiar to pancakes. These products were manufactured in sets of four and each product was coded and then presented to consumers so that they can choose the most appreciable pancakes.

(i). "Focus Group" Tasters

Ten people formed our focus group that enable the selection of best product among the 4 during each tasting test. It is important to note that selected tasters were people used to the consumption of pancakes made with wheat flour. This factor enabled the identification of the smallest difference that can occur between the newly formulated products in order to eliminate undesirable ones.

(ii). Coding and Preparation of Samples

The samples were coded at three digits and selected using random distribution tables. The codes assigned to the

samples were placed at random on the trays. Samples for sensory analysis were produced by the same manipulator, under the same conditions in order to avoid modifications within the products. They were randomly placed in dishes for each taster. Four forms of pancakes including a control (made of 100% wheat flour) and three forms made of plantain flour were presented to each taster. The composition of each pancake based on plantain flour is presented in the next section.

(iii). Hedonic Tests

The sensory tests were carried out in the Postharvest Technology Laboratory of CARBAP. They were done according to the AFNOR XP V 09-500 standard entitled: "General guidelines for the performance of hedonic tests in sensory evaluation laboratories or in controlled conditions involving consumers". The consumer panel consisted of seventy-two (72) people of different levels of schooling, different occupations, males and females of various age groups. All these people resided in the locality of Njombé -

Penja and its surroundings.

During the tests, consumers were invited to taste each form of pancake one after the other after rinsing their mouth each time with water. They then gave their opinions on the colour, taste, texture, aroma and overall appreciation of each product tasted on a 9-point hedonic scale: 9 (I like extremely) to 1 (I do not like) as described by Koko *et al.* [14].

Three tasting sessions were organised. During each session, each taster received a combination of samples, a scorecard and a glass of water to rinse the mouth between two samples. Samples were formulations 4, 13 and 14; respectively codified as follows: 437, 136 and 214 for pancakes made of plantain flour. Code 430 was assigned to formulation 0 representing pancakes made of wheat flour. Consumers were asked to rate the samples on the scorecard. The duly filled out forms were collected at the end of each evaluation session. The data were entered and processed. Minimum training was given to the tasters. The purpose of the short training was: a) to clarify the principle of appreciation, b) to explain how to fill the scoring sheet and c) to present the nature of the sample and the parameters to be assessed.

2.2.5. Statistical Analysis

The analysis of the results was carried out using software R version 3.3.2. for each physicochemical parameter of the flours and the organoleptic properties (colour, taste, texture, flavor and overall product quality) of the pancakes produced. After ANOVA test, the comparison of *Big ebanga* and wheat flour food derivatives was performed by the DUNCAN test to classify treatments in the event of a significant difference. The difference between two data is significant when the actual significance level is less than 5%.

3. Results and Discussions

3.1. Physicochemical Analysis of the Flours

3.1.1. Water Content

Determination of the water content of food products is one of the most important analyses. This is an important factor in maintaining the quality of flour. Its knowledge is useful for the calculation of their nutritional values. It also allows the expression of other analytical determinations (proteins, ash, lipids, etc.) on a uniform basis, based on dry matter [15]. On the other hand, the American Association of Cereal Chemists [16], shows that moisture is an indicator of the suitability of storage.

Figure 4 shows the results of the water contents of the flours used for the production of the pancakes. They are expressed as a percentage after 3 determinations. These averages are 13.24% for wheat flour and 9.93% for *Big ebanga*. It should be noted that there is a significant difference between the water content of wheat flour and that of plantain flour.

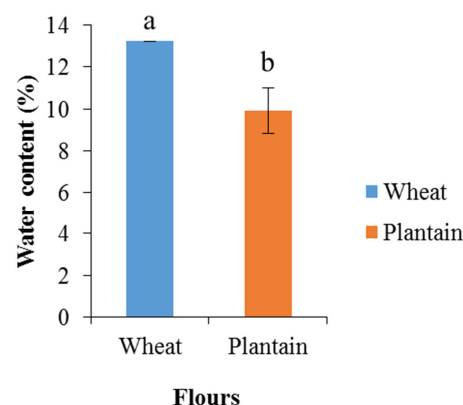


Figure 4. Flour water content.

The common wheat flour used in pancake production has an average water content of 13.24%. This value is included in the range 12.60-14.70% advocated by Souci & coll [17]. It is less than 15.5% which represents the maximum value established by the Codex Alimentarius [18]. In addition, the average water content of plantain (*Big ebanga* cv.) flour is less than 10%. This result was also shown in Chancelle's work [19] on the production and characterization of flours based on sweet potato pulp (*Ipomoea batatas*, Lam), which indicated that the water content was less than 10% for all samples of sweet potato flour and those substituted at different proportions by wheat flour. This could allow a good holding during storage. Furthermore, water content greater than 12% promotes the development of microorganisms. The results of the assessment of the water content of our samples indicate that plantain flour could be better preserve compare to wheat flour.

3.1.2. Total Ash Content

The ash content is an indicator of flour purity. It is related to its rate of extraction and the mineralization of the grains milling. It also defines the commercial types of flour [20, 21].

The mean total ash content of our different flours is 0.49% and 2.05%, respectively (Figure 5). There is a significant difference between the total ash content of wheat flour and that of *Big ebanga*.

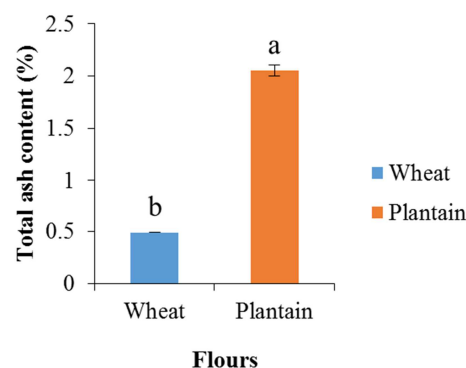


Figure 5. Total ash content of flours.

The total ash content of the common wheat flour (0.49%) is less than 2.29% obtained by Koffi *et al.*[22]. In addition, the ash content of *Big ebanga* flour (2.05%) is almost similar

to that obtained by Kouadio *et al.* [23] on flour produced using another plantain variety namely *Orishele*. The ash content of wheat flour must be less than or equal to 0.50% [21]. This difference between the total ash content of flours may be due to the nature of each matrix and the agricultural conditions of production (type of soil and nature of fertilizers, etc.) as well as the storage conditions (relative humidity of the storage enclosure, type of packaging, etc.).

3.1.3. Total Soluble Solids or Refractive Index

The total soluble solids content gives information on the amounts of soluble sugars present in a sample. In plantain fruits, it enables the determination of pulp ripening stage. The results of total soluble solids are expressed in degree Brix after 3 determinations. Averages are significantly different and are respectively 8.0% for wheat flour and 6.2% for *Big ebanga* (Figure 6).

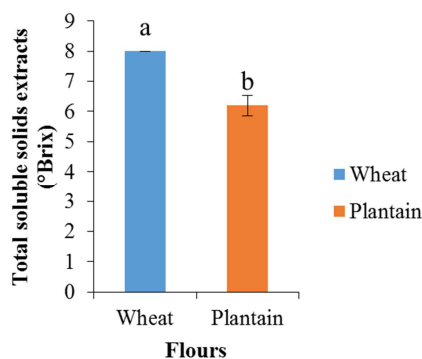


Figure 6. Flour total soluble solid extracts.

The flour total soluble solids contents vary according to plantain variety, the value exhibited by flour made of *Big ebanga* is higher than that obtained by Coulibaly *et al.* [24] on flour produced with pulps of *Orishele* variety. In addition, wheat flour has a higher refractometric index compared to *Big ebanga*.

3.1.4. PH and Total Titratable Acidity

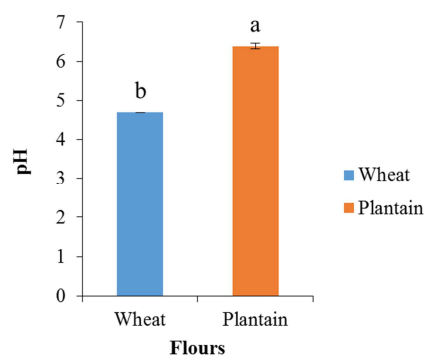


Figure 7. Flour pH.

Hydrogen potential is one of the main factors controlling the speed with which the alteration of products and the growth of microorganisms occur. Their development is very slow at pH below 4. The chemical reactions of degradation of the products are limited in very acidic pH. Figure 7 shows the pH results of the flours used for the production of the

pancakes. Means of wheat flour and *Big ebanga* are 4.69 and 6.39 respectively. However, there is a significant difference between these flours at the 5% threshold.

The pH of wheat and plantain flours used in this study is less than 7. Wheat flour pH value is very low compared to that obtained by Koffi *et al.* [23], meanwhile the pH of the flour made of *Big ebanga* is similar to the value presented by the analyses carried out by Coulibaly *et al.* [24] on flour made of *Orishele* variety. Studies showed that pH values of plantain fruits vary according to variety and decrease according to the ripening stage of the pulps [25].

Acidification is an indicator of deterioration in the technological quality of flour [26]. It may be due to the oxidation of the polyunsaturated fatty acids, which causes an enzymatic degradation of the lipids catalysed by the lipoxygenase and which subsequently induces a rearrangement of the disulfide bonds within the protein network. Figure 8 shows the total titratable acidity concentrations of the different flours used in this study.

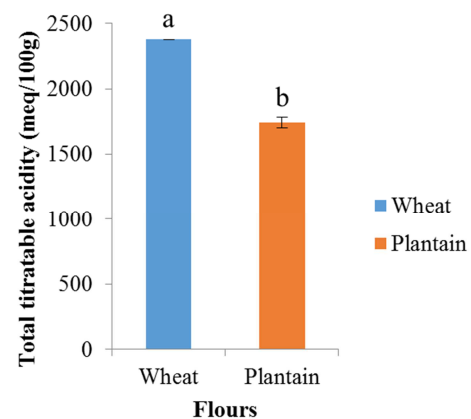


Figure 8. Flour total titratable acidity contents.

The average total titratable acidity contents of plantain (*Big ebanga*) and wheat flours are respectively 1741.2 meq / 100g and 2376.2 meq / 100g. These data are higher compared to those obtained by Soro *et al.* [27] on yam flour (3.5 meq / 100g).

3.2. Formulation and Production of Pancakes

The sixteen starting formulations were divided into five subgroups, each subgroup consisting of four formulations (one formulation made of wheat flour and three made of plantain flour). The pancakes were tested by a panel of tasters composed of 10 people (6 men and 4 women). These people were students, maintenance workers, technicians, researchers and were between the ages of 24 and 55. This preference test consisted of retaining one or two formulations in each subgroup. The retained formulations were again subjected to preference tests by the same tasters and this enabled to retain three formulations most appreciated by the panel of tasters, which are: formulations 4, 13 and 14; respectively codified as follows: 437, 136 and 214. Code 430 was assigned to formulation 0. The composition of each formulation is presented in table 4.

Table 4. Composition of each pancake formulation.

Ingredients	Formulation 0 (code 430)	Formulation 4 (code 437)	Formulation 13 (code 136)	Formulation 14 (code 214)
Butter (g)	25.0	84.2	62.5	62.5
Milk (semi-skimmed) (ml)	250.0	292.2	350.0	350.0
Eggs (unity)	2.0	3.0	2.0	6.0
Sugar (Vanilla) (g)	7.5	7.5	7.5	7.5
Sugar (powdered) (g)	15.0	15	15.0	15.0
Salt (g)	0.5	0.5	0.5	0.5
Baking powder (g)	5.5	5.5	5.5	5.5
Wheat flour (g)	125.0	0.0	0.0	0.0
Plantain flour (g)	0.0	125.0	125.0	125.0

The pancakes produced from formulation 0 served as a control during the sensory tests. The ingredients of each formulation were homogenized in a glass bowl with a whisk for about 15min and then allowed to stand for about 1 hour. The cooking temperature of the pancakes from these formulations was about 60 degrees Celsius and the cooking time of each pancake side was 2 minutes.

3.3. Tasting of Pancakes

The purpose of this tasting was to obtain consumers appreciation on some organoleptic properties such as taste, colour, texture, aroma and global quality of each pancake

formulation. For each criterion, a hedonic scale of 9 points was used: 9 (I like extremely) to 1 (I do not like).

The panel of tasters of the sensory evaluation was made of all social strata with a strong emphasis on the age group of 14-24 years (37%), singles (57%), students (80%) and a strong representation of the workers class. Almost all participants in the tasting session regularly consume the products of bakeries and pastries.

Table 5 shows the average of the different parameters appreciated by the consumers during the tasting of the four forms of pancakes, and Figure 9 shows the appearance of the four types of pancakes.

**Figure 9.** Four forms of pancakes produced.**Table 5.** Average scores for sensory analysis of pancakes samples.

Parameters	Samples			
	Code 430 (Wheat)	Code 437 (Plantain)	Code 214 (Plantain)	Code 136 (Plantain)
Taste	7.11 ^a	5.96 ^b	5.73 ^b	6.29 ^b
Texture	6.97 ^a	6.01 ^b	5.58 ^b	5.58 ^b
Aroma	6.05 ^a	5.39 ^{ab}	5.05 ^b	6.01 ^a
Overall quality	7.29 ^a	6.22 ^b	6.12 ^b	6.76 ^{ab}

The values of the same line followed by different letters present significant differences ($p < 0.05$)

Sensory analysis is an important criterion for evaluating the qualities of new products during their development. For this reason, pancakes produced from plantain flour were evaluated according to four organoleptic criteria. The results of our study presented in Table 4 show that taste and texture differ significantly between pancakes produced from plantain flour and that produced from wheat flour. This difference between these two organoleptic properties (taste and texture) may be due to the nature of the flour used to produce the pancakes. In addition, the aroma of the plantain pancake formulation 136 did not differ

significantly from the control pancake made of wheat flour (code 430). However, formulation 214 shows a significant difference between products 437 and 136. This could be explained by the fact that the formulation was made of two to three times more eggs. Concerning the overall quality, pancakes made of wheat flour are most appreciated by consumers although the value presented by plantain pancakes (formulation 136) was almost similar to that of formulation 430. No significant difference was observed between products 437 and 214.

The sensory profile (Figure 10) shows that sample 430 was

the most appreciated by the 72 tasters followed by sample 136, 437 and 214. The quantities of butter and semi-skimmed milk used during manufacturing of the product 136 were higher compared to those used for product 430. Considering its organoleptic properties, this product may be substituted by formulation 136. Moreover, the work of Yao *et al.*[28] on the effect of the partial substitution of wheat flour by the mature plantain puree (*Musa AAB*) on the quality of the pastry

products shows that the following parameters: crust colour, general appearance, aroma and texture influence the acceptability of the cakes manufactured. In the present study, an overall acceptability of 6.76 with formulation 136 based on 100% plantain flour was obtained compared to 7.29 for pancakes of wheat flour. Table 6 presents the results in percentages of the assessments on the colour of each product by consumers.

Table 6. Appreciations on the colour of each product by consumers.

Colour	Products / Samples			
	Code 430 (wheat)	Code 437 (100% Plantain)	Code 136 (100% Plantain)	Code 214 (100% Plantain)
Pale yellow	70,83%	58,33%	52,7%	51,38%
Gray	36,11%	26,38%	30,55%	36,11%
Brown	2,77%	20,83%	20,83%	16,66%

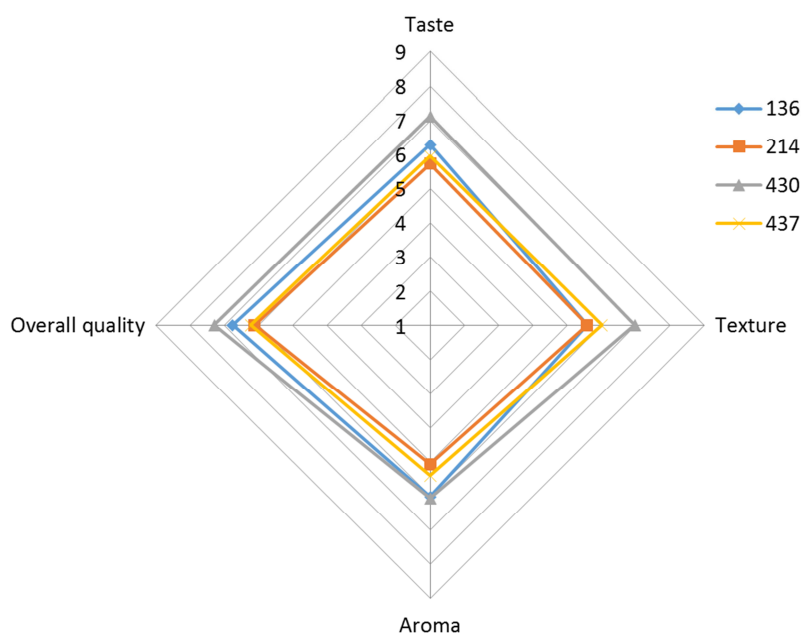


Figure 10. Sensory profile of four forms of pancakes.

Pale yellow pancakes made from wheat flour were appreciated by about 70% of tasters meanwhile more than 50% of consumers appreciated plantain pale yellow pancakes. Furthermore, pancakes with brown colour were less appreciated by consumers. The values of table 5 highlight the importance of colour on the acceptability of a pancake.

4. Conclusion

In order to promote the use of plantain-based flour for the manufacture of food products in Cameroon, this study was carried out on the formulation of pancakes made of plantain flour. Physicochemical parameters (water and ash contents, total soluble solids and total titratable acidity concentrations as well as pH) of wheat and plantain flours were significantly different ($P < 5\%$). The optimization of the production of pancakes made of plantain flour (*Big ebanga* cv.) enabled the selection of three (03) formulations that could be disseminated to small processors of the plantain sector

through extension programs.

The sensory tests of four forms of pancakes (three with plantain flour and one with wheat flour) enabled to retain a better “Formulation 136” most appreciated by consumers. It exhibits organoleptic properties closer to the control “Formulation 430”. Thus, the use of a high proportion of plantain flour into pastry products could help reduce the post-harvest losses of banana and plantain fruits during the period of high production. Given the organoleptic qualities of the pancakes produced using plantain flour, considering the nutritional value of plantain pulps, the resistant starch content of unripe plantain flour and the absence of gluten in banana/plantain flour, the derived pancakes well appreciated by consumers could be recommended to individuals with celiac disease.

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