Available online at http://ajol.info/index.php/ijbcs

Int. J. Biol. Chem. Sci. 8(6): 2478-2493, December 2014

ISSN 1997-342X (Online), ISSN 1991-8631 (Print)

International Journal of Biological and Chemical Sciences

Original Paper

http://indexmedicus.afro.who.int

Characterization and utilization of fermented cassava flour in breadmaking and *placali* preparation

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ABSTRACT

Freshly harvested cassava roots from *yace* cultivar were collected in five regions of Ivory Coast and characterized. These roots were processed into fermented flour. The physicochemical characteristics of flours were evaluated following standard methods and, the ability to be valorised in *placali* preparation and breadmaking were assessed by sensory analysis of products obtained. Both roots and fermented flours were energizing foods. Moisture (6.09-10.49%), protein (1.12-1.57%), ash (0.87-1.39%), fat (0.20-0.51%), total sugars (1.43-1.80%) and cyanide contents (3.33-10.00 mg HCN/kg) of fermented flours were low, while starch (72.79-84.23%), total carbohydrate (93.67-96.45%) and energy (384.53-393.50 kcal/100 g) contents were high. Minerals like phosphorus (78.00-133.33 mg/100 g), calcium (52.66-142.92 mg/100 g), magnesium (27.77-69.26 mg/100 g), iron (2.5-8.20 mg/100 g) and zinc (1.56-6.98 mg/100 g) were available. The sensory evaluation test indicated a significant difference ($p<0.05$) between the *placali* samples in terms of visual appearance, odour, taste, texture and overall appreciation. It is a clear indication that reconstitution proportion (flour to water ratio) affects all the hedonic appreciations assessed. *Placali* prepared from fermented cassava flour were appreciated when reconstitution proportion was within 1:3.5 and 1:3. Composite breads of 85% wheat and 15% cassava fermented flour were accepted by a sensory evaluation panellist. Fermented flour has been successfully used in breadmaking and *placali* preparation. It is a means of diversifying cassava utilization form.

Keywords: Gelatinized food, *yace* cultivar, sensory evaluation, composite flour, bread.

INTRODUCTION

Cassava (*Manihot esculenta* Crantz) is an important tropical tuber crop (Pillai et al., 2013). It is mainly cultivated for its roots, which constitute an energizing food for over 800 million people in the world (Burns et al., 2010). This fact is certainly due to their high carbohydrate contents, to the ability of the plant to grow on poor soil and its drought resistance. Cassava is a higher producer of carbohydrate per hectare than the main cereal crops and can be grown at a considerably

DOI : http://dx.doi.org/10.4314/ijbcs.v8i6.11

lower cost (Ukwuru and Egbonu, 2013). About of 2.5 million tons per year of West African productions were from Côte d'Ivoire (Ivory Coast) (Faostat, 2013). In this country, edible cassava roots can be processed into various products such as *attieke*, *gari*, *fufu*, *foufou*, *foutou*, flour, *kongonde*, *placali*, *Attoukpou, Akpessi and Bedekouman* (Amani and Kamenan, 2003).

One of the most commonly used products is *placali*. It is a fermented and gelatinized cassava product. *Placali* is the second well-known cassava byproduct after *attieke* (Koffi-Nevry et al., 2007). Despite this importance, the production of this indigenous food is not so easy. Multiple unit operations are needed and constitute tiresome job for manufacturers or housewives. That leads sometimes to *placali* with inconstant quality. It is therefore necessary to produce fermented flour that can be used very easily, in *placali* preparation as instant flour. Earlier reports mentioned the feasibility of such process (Tanya et al., 2006; Etudaiye et al., 2009; Koko et al., 2012). The use of fermented flour in *placali* preparation can add value to cassava with corresponding quality and overcome other difficulties. In addition, rapid urban growth places a dynamic challenge into instant flour (Etudaiye et al., 2009).

On the other hand, bread is an important staple food. It is a baked product traditionally produced from wheat flour. In Ivory Coast, wheat represents the top of the food importation with 453,980 tons/year and costs 185.4 million dollars (Faostat, 2011). Because of the global economic recession, attention is focused on substituting wheat flours in bread and other baked foods with locally cultivated crops (Oladunmoye et al., 2010). Thus, unfermented cassava flour has been used successfully in breadmaking, as partial substitute of wheat (Sanni et al., 2005; Eddy et al., 2007). The use of composite flour in breadmaking as cassava/wheat flour could help developing countries decreasing cereal importations and finally saving money in tropical areas. Touko et al. (2007) and Ohimain (2014) reported that utilization of cassava flour, as a partial substitute for wheat in bread seems to be benefit. Then, in this study, the utilization of fermented cassava flour in breadmaking highly appreciated by consumers is also investigated.

The aim of the present study was to characterize and use fermented cassava flour in breadmaking and *placali* preparation and finally, to evaluate the acceptability of breads and placali obtained.

MATERIALS AND METHODS

Raw materials

Fresh cassava roots from *yace* variety (a local cultivar) were used in this study. These roots were harvested 12 months after cultivation and from five regions of Côte d'Ivoire, *i.e. Belier*, *Lôh-djiboua*, *Gôh*, *Guemon* and *Nawa*. In each region, three samples of roots were extracted. In total, fifteen samples were collected.

Preparation of cassava inoculum

The cassava inoculum was produced following traditional method described by Koko (2012). In this method, the entire fresh roots were washed and braised until being cooked. These roots were peeled and cooled at ambient temperature. After that, the peeled roots were packaged and let for three or four days at ambient temperature (28-30 °C). At the end of this period, the product or cassava inoculum is retired, rid of undesirable parts and ground before using.

Production of fermented flour

The processing of roots into fermented flour was described by koko et al. (2010). In this method, Fresh cassava roots were peeled with a knife and cut into large longitudinal pieces. These pieces were ground and a cassava inoculum previously obtained, was added at 8% dough (Aboua, 1995). The mass was packed into bags and let for three days at ambient temperature (28-30 °C), without any compression. The fermented dough was then removed and squeezed. When the dough was sufficiently pressed, it was oven-dried for 48 hours at 55 °C. The dried product was ground and sieved using a 200 µm aperture size to obtain the fermented flour.

Physicochemical analyses

The following analyses were conducted to characterize the cassava roots and derivative fermented flours. Moisture, ash, starch, proteins and lipids contents were evaluated using BIPEA (1976) methods. Cyanide and total sugars contents were carried out following the FAO (1956) and Dubois et al. (1956) methods respectively. Titratable acidity and pH were determined according to method described by Dufour et al. (1996). Total carbohydrate contents were carried out using method described by Bertrand (1913). Caloric energy was calculated according to the Atwater general factor system (FAO, 2003). The system uses a single factor for each of the energy-yielding substrates (protein, fat, carbohydrate) regardless of the food in which it is found. The energy values are 4.0 kcal/g for protein, 9.0 kcal/g for fat and 4.0 kcal/g for carbohydrates. Minerals such as calcium (Ca), magnesium (Mg), zinc (Zn), iron (Fe) and phosphorus (P) were quantified by Atomic Absorption Spectrometer (Varian AA 20, Australia) and Spectrophotometer (UV/Visible Jasco V 530i) respectively, after digestion of samples following IITA (1981) method. The ratio Ca/P was evaluated by calculation.

Breadmaking process

Different proportions of fermented cassava flour and wheat flour were used in this study. In composite flour, fermented cassava levels were 30% for the first formulation and 15% for the second one. The following formula was used to prepare bread dough:

- 50 kg of composite flour (fermented cassava/wheat flour);
- 1 kg of salt;
- 500 g of yeast;
- 500 g of industrial bread improver;
- Water (the sufficient quantity to achieve the right consistency).

This formula is currently used by bakers to prepare 100% wheat bread dough in the production unit. After preparation, these ingredients were blended slowly in a kneading machine (MAHOT, France) for 15 min. About 30 min are needed for dough mixing until smooth and well developed. The dough is retired and transferred to a floured surface at room temperature for 5 min. After this rest, the dough was divided into 405 rounded portions. These portions were let to ferment on the floured surface for 10 min. After this first fermentation, each portion was introduced in an apparatus for shaping and the dough roll obtained was manually transformed into the desired shape (baguette and round loaf bread). These dough rolls were disposed on support, covered with black tarp and let to ferment for 1 h 40 min at room temperature. After this fermentation period, each fermented dough was scarified and baked in baker's oven (BONGARD). About 23 min and 28 min are needed for baguettes and round loaf breads respectively. Finally, the breads were cooled in breadbaskets at room temperature, for 1 h 05 min.

Preparation of *placali* samples

Many trials were made to obtain *placali* preparation conditions (flour to water ratio, quantity of water, cooking time). After this, four *placali* samples were prepared by adding a fixed quantity of fermented cassava flour (50 g) in a variable quantity of boiled water. Cooking time was fixed at 12 minutes for all the *placali* samples. The proportion of reconstitution was then:

- 1 part of flour in 2 parts of water (1:2) for sample F50;
- 1 part of flour in 3 parts of water (1:3) for sample F33;
- 1 part of flour in 3.5 parts of water (1:3.5) for sample F28;
- 1 part of flour in 4 parts of water (1:4) for sample F25.

The *placali* samples obtained were disposed on plates for sensory analysis.

Sensory analysis

The *placali* samples and cassava/wheat breads from different formulations were subjected to sensory evaluation. A panel of 60 non-trained persons was randomly selected to evaluate the acceptance of *placali* samples and breads prepared from fermented cassava flour. These assessors were selected between regular consumers of such products. They were conversant with analyzed products. The different *placali* samples (F50, F33, F28 and F25) were evaluated for their taste, odour, texture, overall appreciation and visual appearance. In the same mood, the baguettes (B11) and round loaf breads (R12) obtained from the second formulation (fermented flour level of 15%) were analyzed. The evaluation of these all samples was based on 9-point hedonic scale (Harry and Hildegarde, 2010) where 9 stood for 'like extremely', 8 'like very much', 7 'like moderately', 6 'like slightly', 5 'neither like nor dislike', 4 'dislike slightly', 3 'dislike moderately', 2 'dislike very much' and 1 'dislike extremely'.

Statistical analysis

Data obtained from the physicochemical characterization and the sensory analysis, were subjected to statistical analyses using STATISTICA 7.1 software package. Analysis of variance (ANOVA) was done. If necessary, Tukey HSD multiple comparison tests were done to determine significant differences at 5% probability between means. Multidimensional analysis of variance (MANOVA) was also done. It is a generalization of analysis of variance (ANOVA) method to one or several factors (qualitative variables) in which two or several dependent variables are measured simultaneously. The MANOVA deals with comparing different means in order to identify if they are different or equal.

RESULTS

Physicochemical characteristics of cassava roots and their derivative fermented flours

The Table 1 presents the results of the physicochemical characterization of cassava roots from five regions. As shown in this table, moisture content of *yace* roots varied from 60.12±0.62 (*Nawa* region) to 66.39±2.46% (*Gôh* region). It was observed that roots of *yace* cultivar contained high moisture. In addition, there was no significant difference ($p>0.05$) between moisture content of roots from these regions. The roots contain also proteins, which values varied from 1.82±0.13 (*Lôh-djiboua* region) to 2.43±0.10% (*Belier* region). Whatever is the region, there was no significant difference ($p<0.05$) between protein contents of roots. Cassava roots had low protein contents. The values of pH were between 5.96±0.05 and 6.46±0.06 recorded in *Gôh* and *Nawa* regions respectively. This variation is revealed to be statistically significant ($p<0.05$). Titratable acidity of roots varied from 1.42±0.33 to 8.35±1.28 meq/100 g. There was a significant difference ($p<0.05$) between these values of acidity (Table 1). The lowest value was recorded in *Nawa* region (1.42±0.33 meq/100 g) while the highest one, reached 8.35±1.28 meq/100 g in *Gôh* region. The lipid contents of *yace* roots were situated between 0.41±0.03 (*Lôh-djiboua* region) and 0.70±0.04% (*Nawa* region). There was a significant difference ($p<0.05$) between the lipid contents of the roots from different regions. The lipid contents of the roots were low. It was observed in *yace* roots, values ranging from 1.75±0.11 to 2.89±0.37% and from 1.63±0.16 to 2.08±0.11% for ash and total sugars respectively. Ash and total sugars contents were low. The analysis of variance showed that there was a significant difference ($p<0.05$) between the ash contents of the roots. In the same mood, a significant difference ($p<0.05$) was observed between the total sugars contents. The roots from *Gôh* region recorded the highest values of ash (2.89±0.37%) and total sugars (2.08±0.11%).

The lowest ones were from *Belier* region for total sugars and *Lôh-djiboua* region for ash. Cyanide contents of *yace* roots varied from 101.66±11.54 to 118.44±16.19 mg/kg in *Lôh-djiboua* and *Guemon* regions respectively. Statistical analysis revealed that there was no significant difference ($p>0.05$) between the cyanide contents of roots from *yace* cultivar, whatever is the region. Cassava roots contain carbohydrate with values ranging from 93.30±0.43% (*Gôh* region) to 94.85±0.29% (*Nawa* region). As shown in Table 1, the variation in carbohydrate contents was not statistically significant ($p>0.05$). Cassava roots from *yace* cultivar had high carbohydrate content. The starch content of the roots varied from 69.31±1.20 to 81.80±1.56%. There was a significant difference ($p<0.05$) between these starch contents. The highest value of starch content was recorded in *Belier* region whereas the lowest one was obtained in *Gôh* region. The caloric energy of roots varied from 386.90±1.79 (*Gôh* region) to 391.30±1.74 kcal/100 g (*Nawa* region). Whatever is the region, no significant difference ($p>0.05$) existed between caloric energy of these roots. It was observed that the values of phosphorus ranged from 95.83±8.03 (*Guemon* region) to 156.66±5.20 mg/100 g (*Nawa* region). This variation was statistically significant ($p<0.05$). The Mg values varied from 50.66±3.05 to 142.86±17.31 mg/100 g. It was observed that there was a significant difference ($p<0.05$) between the values of Mg recorded in *yace* roots. The highest value of Mg was recorded in *Guemon* region while the lowest one was obtained in *Belier* region. The Zn content ranged from 1.80±0.19 to 7.51±0.37 mg/100 g in *Belier* and *Gôh* regions respectively. There was a significant difference ($p<0.05$) between zinc content of roots from *yace* cultivar. The calcium contents varied from 73.66±5.50 (*Lôh-djiboua* region) to 170.33±14.56 mg/100 (*Nawa* region). In addition, the statistical analysis revealed that there was a significant difference ($p<0.05$) between the values of calcium content. The Ca/P ratio in *yace* roots varied from 0.64±0.01 (*Lôh-djiboua* region) to 1.29±0.20 (*Guemon* region). This variation was statistically significant ($p<0.05$). The iron content of roots varied from 4.42±0.12 (*Gôh* region) to 8.83±0.05 mg/100 g (*Nawa* region). In *yace* roots, it was observed a significant difference ($p<0.05$) between the values of iron content. In addition, the phosphorus content seems to be the highest between minerals assessed whereas zinc content has the lowest value. Statistical analysis was done on the whole physicochemical characteristics and the results are presented in Table 2. This analysis showed that roots from these five regions were significantly different ($p<0.05$).

The results of the physicochemical characterization of fermented cassava flours from *yace* cultivar collected in five regions of Ivory Coast are presented in Table 3. As shown in this table, the moisture content of fermented flours varied from 6.09±0.06 (*Guemon* region) to 10.49±0.65% (*Belier* region). There was a significant difference ($p<0.05$) between moisture content of fermented flours. The values of pH were within 3.95±0.03 (*Gôh* region) and 4.42±0.03 (*Guemon* region). The observed values were statistically different ($p<0.05$). The fermented flour samples had protein contents ranging between 1.12±0.06 (*Nawa* region) to 1.57±0.17% (*Gôh* region). This variation is revealed to be statistically significant ($p<0.05$). The lipid contents of flours ranged from 0.20±0.03 (*Nawa* region) to 0.51±0.06% (*Belier* region). Statistical analysis showed a significant difference ($p<0.05$) between these values. All the values of lipid content were very low. The ash and total sugars contents varied from 0.87±0.02 (*Nawa* region) to 1.39±0.01% (*Guemon* region) and from 1.43±0.05 (*Belier* region) to 1.80±0.11% (*Lôh-djiboua*), respectively. These variations were revealed to be statistically significant ($p<0.05$). The cyanide content of cassava flours ranged between 3.33±5.77 and 10.00±8.66 mg HCN/kg while the starch contents varied from 72.79±0.72 (*Gôh* region) to 84.23±2.80% (*Nawa* region). It was observed that there was a significant difference ($p<0.05$) between the values of starch content. The carbohydrate contents ranged from 93.67±1.00 to 96.45±0.41% in *Belier* and *Nawa* regions respectively. This variation was statistically significant ($p<0.05$). In addition, all the carbohydrate contents recorded in fermented cassava flours were high. The caloric energy varied between 384.53±4.70 (*Belier* region) and 393.50±0.46 kcal/100 g (*Guemon* region). Statistical analysis showed that there was a significant difference ($p<0.05$) between the caloric energy of fermented flours assessed. Phosphorus and calcium contents of the flours ranged from 78.00±10.44 (*Lôh-djiboua* region) to 133.33±5.20 mg/100 g (*Nawa* region) and from 52.66±3.21 (*Lôh-djiboua* region) to 142.92±32.06 mg/100 g (*Nawa* region) respectively (Table 3). The variation in phosphorus contents of flours was statistically significant ($p<0.05$). In the same mood, calcium levels in flours varied significantly ($p<0.05$) from a region to a region. The Ca/P ratio in *yace* flours varied from 0.68±0.07 (*Lôh-djiboua* region) to 1.07±0.25 (*Nawa* region). This variation was statistically significant ($p<0.05$). The iron content of flours ranged between 2.5±0.45 (*Gôh* region) and 8.20±0.42 mg/100 g (*Nawa* region). It was observed that there was a significant difference ($p<0.05$) between these values. The observed values of zinc content ranged from 1.56±0.04 (*Lôh-djiboua* region) to 6.98±0.10 mg/100 g (*Gôh* region). Statistical analysis showed that there was significant difference ($p<0.05$) between zinc contents of flours from different regions. The fermented flours contained also magnesium, which values ranged from 27.77±0.58 (*Nawa* region) to 69.26±1.41 mg/100 g (*Gôh* region). This variation was statistically significant ($p<0.05$). In total, significant differences ($p<0.05$) were recorded between most of the physicochemical parameters of the flours. The multidimensional analysis of variance (MANOVA) done on the physicochemical characteristics showed a significant difference ($p<0.05$) between these flours (Table 4).

Sensory analysis of cassava products

Processing of fermented cassava flour into *placali* showed ease of preparation. The *placali* samples prepared using fermented flours were submitted to sensory analysis. The results are presented in Table 5. As shown in this table, the significant differences ($p<0.05$) between the *placali* samples were on visual appearance, odour, taste, texture and overall appreciation. Sample F28 recorded high scores for the above parameters. Besides, difference of appreciation between sample F28 and sample F33 was only on the taste. Samples F28 and F33 recorded the scores of 6.83 ± 1.5 and 5.85 ± 1.86 for the taste respectively. Low scores were recorded for visual appearance, odour, taste, texture and overall appreciation of *placali* sample F50. The MANOVA table from hedonic appreciation scores showed that all the *placali* samples assessed were statistically different ($p<0.05$) (Table 6).

Breads obtained from the first formulation (30% of fermented cassava flour as partial substitute of wheat) were not allowed to score because of their bad visual appearance, shape and other hedonic appreciations. The *cassava/wheat* bread samples prepared using 15% of fermented flour and 85% of wheat flour were submitted to sensory analysis. The hedonic appreciation scores are shown in Table 7. As shown in this table, the sensory evaluation test indicated a significant difference ($p<0.05$) between the bread samples in terms of visual appearance, odour, taste, texture and overall appreciation. The round loaf breads (R12) recorded the highest scores for visual appearance, odour, taste, texture and overall appreciation. It was observed that all the scores for bread samples were high, more than seven (7) on 9-point hedonic scale.

Table 1: Physicochemical characteristics of cassava roots from *yace* cultivar coming from five regions of Ivory Coast.

	Regions				
Parameters	**Belier**	**Lôh-djiboua**	**Gôh**	**Guemon**	**Nawa**
Moisture (%)*	62.55±0.64[a]	61.13±0.36[a]	66.39±2.46[a]	64.91±5.41[a]	60.12±0.62[a]
Proteins (%)	2.43±0.10[a]	1.82±0.13[a]	2.24±0.06[a]	2.10±0.42[a]	2.05±0.32[a]
pH	6.43±0.11[b]	6.45±0.06[b]	5.96±0.05[a]	6.33±0.09[b]	6.46±0.06[b]
Acidity (meq/100g)	4.62±0.94[b]	5.64±0.33[b]	8.35±1.28[c]	4.80±0.20[b]	1.42±0.33[a]
Lipids (%)	0.53±0.05[bc]	0.70±0.04[d]	0.52±0.04[abc]	0.65±0.05[bcd]	0.41±0.03[ab]
Ash (%)	2.47±0.11[bcd]	1.88±0.17[abc]	2.89±0.37[bd]	2.52±0.23[bcd]	1.75±0.11[a]
Total sugars (%)	1.63±0.16[a]	2.06±0.07[b]	2.08±0.11[b]	1.97±0.07[b]	2.05±0.10[b]
Cyanide (mg/kg)*	105.00±10[a]	101.66±11.54[a]	108.33±7.63[a]	118.44±16.19[a]	106.66±10.40[a]
Starch (%)	81.80±1.56[cd]	74.84±0.41[bc]	69.31±1.20[a]	76.95±2.24[bc]	77.71±1.61[bcd]
Carbohy-drates (%)	93.42±1.48[a]	94.23±0.33[a]	93.30±0.43[a]	93.60±0.41[a]	94.85±0.29[a]
Energy (kcal/100 g)	388.25±6.41[a]	390.58±0.68[a]	386.90±1.79[a]	388.67±0.32[a]	391.30±1.74[a]
P (mg/100 g)	98.66±16.25[a]	114.66±10.26[a]	150.66±14.04[b]	95.83±8.03[a]	156.66±5.20[b]
Mg (mg/100 g)	50.66±3.05[a]	51.00±2.00[a]	75.50±3.77[a]	142.86±17.31[b]	68.18±28.51[a]
Fe (mg/100g)	6.82±2.05[abcd]	5.73±0.15[abc]	4.42±0.12[abc]	7.24±0.98[abd]	8.83±0.05[ad]
Zn (mg/100 g)	1.80±0.19[a]	1.96±0.09[a]	7.51±0.37[d]	3.96±0.66[b]	5.95±0.17[c]
Ca (mg/100g)	92.33±1.52[abd]	73.66±5.50[ab]	137.00±15.00[cde]	124.91±29.4[bcd]	170.33±14.56[ce]
Ca/P	0.94±0.12[bc]	0.64±0.01[ab]	0.90±0.01[abc]	1.29±0.20[cd]	1.08±0.05[bcd]

Tabulated values are means of triplicate ± Standard Deviation (SD); (*) Fresh matter basis.
Values with different letters in each row are significantly different ($p<0.05$)

Table 2: MANOVA table from physicochemical characteristics of *yace* roots from five regions of Ivory Coast.

Error source	Test	Value	F	Degree of freedom	P
Intercept	Wilk	0.000001	189228.2	10	0.001789
Regions	Wilk	0.000000	14.8	40	0.001853

Effect is significant at p<0.05.

Table 3: Physicochemical characteristics of fermented cassava flours from *yace* cultivar coming from five regions of Ivory Coast.

	Regions				
Parameters	**Belier**	**Lôh-djiboua**	**Gôh**	**Guemon**	**Nawa**
Moisture (%)*	10.49±0.65[bd]	9.14±0.17[cde]	9.82±0.11[bcd]	6.09±0.06[a]	8.71±0.03[ce]
Proteins (%)	1.31±0.09[abcd]	1.29±0.17[abc]	1.57±0.17[cd]	1.44±0.08[bcd]	1.12±0.06[ab]
pH	4.00±0.05[abc]	3.98±0.03[ab]	3.95±0.03[ab]	4.42±0.03[d]	4.09±0.03[ac]
Acidity (meq/100 g)	14.93±0.75[a]	15.15±0.61[a]	14.85±0.24[a]	9.79±0.64[b]	12.48±0.58[c]
Lipids (%)	0.51±0.06[bc]	0.41±0.03[abc]	0.35±0.05[ac]	0.36±0.04[ac]	0.20±0.03[d]
Ash (%)	1.15±0.05[b]	1.21±0.09[b]	1.21±0.02[b]	1.39±0.01[c]	0.87±0.02[a]
Total sugars (%)	1.43±0.05[a]	1.80±0.11[b]	1.65±0.11[ab]	1.78±0.09[b]	1.73±0.11[b]
Cyanide (mg/kg)*	10.00±8.66[a]	-	-	3.33±5.77[a]	-
Starch (%)	83.16±1.95[b]	81.35±0.65[b]	72.79±0.72[a]	80.72±0.78[b]	84.23±2.80[b]
Carbohy-drates (%)	93.67±1.00[a]	96.03±0.08[b]	95.75±0.38[bb]	96.10±0.13[b]	96.45±0.41[b]
Energy (kcal/100 g)	384.53±4.70[a]	393.01±0.41[b]	392.47±1.11[b]	393.50±0.46[b]	392.16±1.12[b]
P (mg/100 g)	86.00±4.58[ab]	78.00±10.44[a]	100.66±8.08[b]	86.66±9.46[ab]	133.33±5.20[c]
Mg (mg/100 g)	66.66±1.15[a]	38.66±6.65[bc]	69.26±1.41[a]	32.04±0.37[bcd]	27.77±0.58[cd]
Fe (mg/100 g)	3.78±0.15[ab]	3.15±0.23[ab]	2.5±0.45[b]	6.58±0.39[c]	8.20±0.42[d]
Zn (mg/100 g)	1.68±0.17[a]	1.56±0.04[a]	6.98±0.10[c]	3.29±0.40[ab]	4.02±1.79[b]
Ca (mg/100 g)	62.66±3.05[ab]	52.66±3.21[a]	93.00±6.08[b]	79.40±1.67[ab]	142.92±32.06[c]
Ca/P	0.72±0.04[a]	0.68±0.07[a]	0.91±0.01[ab]	0.92±0.10[ab]	1.07±0.25[b]

Tabulated values are means of triplicate ± SD; (*) Fresh matter basis; (-) Not determined; Values with different letters in each row are significantly different (p<0.05).

Table 4: MANOVA table from physicochemical characteristics of *yace* fermented flours.

Error source	Test	Value	F	Degree of freedom	p
Intercept	Wilk	0.00000	1351195	10	0.000669
Regions	Wilk	0.00000	56	40	0.000050

Effect is significant at $p<0.05$.

Table 5: Hedonic appreciation scores of *placali* samples from fermented cassava flour.

	Hedonic appreciation scores				
***Placali* samples**	**Visual appearance**	**Texture**	**Odour**	**Taste**	**Overall appreciation**
F25	5.71 ± 1.86^{b}	5.23 ± 2.48^{b}	5.9 ± 1.73^{b}	5.97 ± 1.97^{b}	5.41 ± 2.08^{b}
F28	6.3 ± 1.83^{b}	6.66 ± 1.78^{c}	6.4 ± 1.67^{b}	6.83 ± 1.5^{c}	6.68 ± 1.58^{c}
F33	5.9 ± 1.44^{b}	6.21 ± 1.54^{c}	5.76 ± 1.45^{b}	5.85 ± 1.86^{b}	6.23 ± 1.59^{c}
F50	3.53 ± 1.89^{a}	3.2 ± 1.65^{a}	4.73 ± 1.95^{a}	4.73 ± 1.92^{a}	3.68 ± 1.3^{a}

Tabulated values are means ± SD of sixty determinations. The values with different letters in each column are significantly different ($p<0.05$).

Table 6: MANOVA table from hedonic appreciation scores of *placali* samples.

Error source	Test	Value	F	Degree of freedom	p
Intercept	Wilk	0.058779	742.9944	232	0.00
Placali samples	Wilk	0.551364	10.2830	640	0.00

Effect is significant at $p<0.05$.

Table 7: Hedonic appreciation scores of bread samples.

	Hedonic appreciation scores				
Bread samples	**Visual appearance**	**Texture**	**Odour**	**Taste**	**Overall appreciation**
B11	7.15 ± 1.19[a]	7.16 ± 0.88[a]	7.41 ± 1.01[a]	7.82 ± 0.95[a]	6.86 ± 0.83[a]
R12	8.61 ± 0.49[b]	8.2 ± 0.6[b]	8.45 ± 0.59[b]	8.57 ± 0.5[b]	8.4 ± 0.58[b]

Tabulated values are means ± SD of sixty determinations. The values with different letters in each column are significantly different ($p<0.05$).

DISCUSSION

The physicochemical characterization revealed that cassava roots of *yace* cultivar contained high moisture. The moisture content of freshly harvested roots was found to be 75.4 % wet basis (Kajuna et al., 2001). In this study, the observed values were below. Ladeira et al. (2013) found values of 73.25±0.08% and 75.62±1.08% in roots from *Maranhense II* and *Santarém SI* cultivars respectively. In addition, there was no significant difference between moisture content of roots from these regions. Variations in the moisture content of the fresh roots were observed with values ranging from 33.14% to 45.86% (wb) in *Bankye fitaa* and *Broni bankye*, two Ghanaian cultivars respectively (Emmanuel et al., 2012). The high moisture content of roots is a serious issue as it is an indication of a rapid deterioration after harvested. It is well-known that cassava roots have low protein contents. Similar results were recorded in this study. Emmanuel et al. (2012) found in the cassava roots from *Bankye fitaa* variety an average protein value of 3.48±0.47%. The variation in pH value of cassava roots is revealed to be statistically significant. Therefore, the pH values of *yace* roots varied from a region to a region. This variation was certainly due to regional parameters such as soil, rainfall or cultural practices. According to Soares et al. (1992), *yace* roots were low-acid foods (pH>4.5). As shown in pH values, Titratable acidity of roots varied widely from a region to a region. In addition, there was a significant difference between the lipid contents of the roots from the five regions. Despite the significant difference, the lipid contents of the roots were so low. This result is similar to that reported by Adepoju et al. (2010), who found in cassava roots an average value of 0.45% on dry weight basis. In *yace* roots, ash and total sugars contents were low. The analysis of variance showed that there was a significant difference between the ash contents of the roots. Then, ash content of *yace* cultivar varied from a region to a region. The variation of ash content could be due to regional parameters as soil composition and cultural practices. In this study, the ash contents of roots were higher than the values ranging from 0.09 to 0.17% reported by Souza et al. (2013) in three sugary cassava landraces. Sahore and Nemlin (2010) found in cassava roots (sweet and bitter species) the values of ash content ranging from 2.49 to 2.53%. These values were within those recorded in this study. In the same mood, a significant difference was observed between the values of total sugars. The total sugar contents of roots from *yace* cultivar were lower than the values reported by Souza et al. (2013). These authors found values ranging from 3.92 to 5.84% in three sugary cassava landraces in Brazil. In this study, regional parameters do not affect the cyanide contents of cassava roots. Indeed, Statistical analysis revealed that there was no significant difference between the cyanide contents of roots from *yace* cultivar, whatever is the region. According to Purseglove (1968), the cassava roots in which cyanide content is up to 100 mg/kg, could be classified as toxic variety. Then, cassava roots from *yace* cultivar are toxics. It is therefore necessary to process this kind of roots before using it in human consumption. Despite this toxicity, cassava roots from *yace* cultivar had high carbohydrate content. These results are in agreement with earlier report (Sahore and

Nemlin, 2010). These authors found average values of 94.62% and 94.70% in cassava roots from sweet and bitter species respectively. Besides, the dominant fraction of the carbohydrate was starch. The starch content of cassava roots varied significantly from a region to a region. This variation could be explained by the influence of regional parameter as rainfall. Indeed, Bakayoko et al. (2009) mentioned the influence of rainfall on the dry matter content, which is highly represented by starch in cassava roots. The roots are energizing foods due certainly to their high carbohydrate contents. In this study, the values of caloric energy were close to those recorded in cassava roots, ranging from 371.49 to 371.72 kcal/100 g (Sahore and Nemlin, 2010). Whatever is the region, there was no significant difference between caloric energy of these roots. In addition, cassava roots from *yace* cultivar contain minerals (P, Mg, Fe, Zn, and Ca). Zoumenou et al. (1999) reported in roots from *Bonoua* cultivar, an Ivorian sweet specie, the value of phosphorus to be 140±0.30 mg/100 g. This value of phosphorus was within the range (95.83 - 156.66 mg/100 g) recorded in this study. Montagnac (2009) reported an average Mg value of 80 mg/100 g, which is situated between the range obtained in this study. An average value of 4.1 mg Zn/100 g is reported in cassava roots (Montagnac et al., 2009). Similar result is found in this study. As shown in P and Mg contents, there was a significant difference between zinc contents of roots from *yace* cultivar. Chavez et al. (2000) found in 20 cassava genotypes from the *Centro Internacional de Agricultura Tropical* (CIAT) in Colombia, values of calcium content ranging from 37.9 to 94.5 mg/100 g. These values were within those recorded in the present study. In addition, the statistical analysis revealed that there was a significant difference between calcium contents of *yace* roots. The variation in Ca/P ratio is also showed to be statistically significant. Despite the significant difference between the Ca/P ratios of the roots from five regions, all of them were below those ranging from 1.60 to 5.48 reported in cassava roots by Montagnac et al. (2009). The highest value of Ca/P ratio (1.29±0.20) recorded in this study is close to 1.5, which is considered ideal for optimal growth of infants and children (EFSA 2005). In this study, the values of iron content were below those reported by Sarkiyayi and Agar (2010). These authors found values ranging from 18 to 30 mg/100 g in roots from bitter and sweet species respectively. The different minerals assessed varied significantly from a region to a region. The variation in mineral content of cassava roots could be due to regional parameters (e.g., soil composition, cultural practices). The phosphorus content seems to be the highest between minerals assessed whereas zinc content has the lowest value. Statistical analyses done on the whole physicochemical characteristics showed that roots from these five regions were significantly different. The characteristics of *yace* roots, which varied from a region to a region, were pH, titratable acidity, lipid, ash, total sugars, starch and minerals contents. It is well-known that processing roots into flours that could be used in breadmaking and *placali* preparation needs starchy products. Thus, the roots from *Belier*, *Lôh-djiboua*, *Guemon* and *Nawa* regions, which contain the highest value of starch, could be used in flour production.

The physicochemical characteristics of fermented cassava flours were evaluated. The moisture contents of flours were low. In addition, it was observed a significant difference between these values. Despite the significant difference between the moisture contents of the flours, all of them were within the recommended standard (less than 12%) for the edible cassava flour (Sanni et al., 2005). According to Soares et al. (1992), all the flours assessed were acid (less than 4.5). Adebayo-Oyetoro et al. (2013) found values of pH ranging from 4.05 to 5.55 in *lafun* obtained from Nigerian processing sites and markets. These values are relatively higher than those recorded in this study, due certainly to the fermentation process. Babajide and Olowe (2013) reported an average value of 3.34±0.04 in *lafun* flour. The protein contents of flours were statistically different. Although the significant difference between protein contents, all of them were lower than 10.9% recorded by Oboh and Akindahunsi (2003) in cassava flour subjected to *Saccharomyces cerevisae* solid media fermentation. As shown in cassava roots, all the values of lipid content of fermented flours were also low. It is well-known that cassava flours are poor in lipids. Oladunmoye et al. (2010) reported similar results (1.01±0.01) in cassava flour. The values of ash content of flours were in agreement with Codex Alimentarius (1991) standard for edible cassava flour (less than 3%). Apea-Bah et al. (2011) reported ash content of flours ranging between 0.80 and 1.47% in *Afisiafi* cultivar, a Ghanaian cassava variety. Similar results were recorded in this study. The values of cyanide contents recorded were within the recommended standard for edible cassava flour (less than 10 mg HCN/kg). Then, these fermented flours are safe for human consumption. It was observed that there was a significant difference between the starch contents of fermented flours. The values of starch content recorded in *Nawa*, *Guemon*, *Lôh-djiboua* and *Belier* regions were close to 86.25%, reported by Perez et al. (2007) in raw flour. Starch represents the main constituent of carbohydrate. Besides, it was observed that there was a significant difference between the values of carbohydrate in fermented flours. Despite the significant difference, all the carbohydrate contents recorded in fermented cassava flours were high. Then, fermented cassava flours were starchy products. As shown in roots from different regions, their derivative fermented flours were also energizing foods. The high values of energy in cassava flour could help developing countries fighting against hungry when using it as foodstuff. Nevertheless, it is necessary to accompany this foodstuff with both source of proteins (i.e., plants and animals). Adeniji et al. (2007) found in Nigerian grated cassava the values of 105 mg/100 g and 78.3 mg/100 g for phosphorus and calcium respectively. These values were within those recorded in the present study. All of the Ca/P ratios were below the value of 1.5 reported in human milk (EFSA 2005). However, these values were close to 0.7, the optimal value for the absorption of the both minerals according to Javillier et al. (1967). In addition, the values of iron content of flours were lower than 15.67 mg/100 g reported by Adeniji et al. (2007) in grated cassava. These authors reported in the same product the value of zinc content to be 0.73 mg/100 g. In this study, the observed zinc contents were much higher. Statistical analysis showed that there was a significant difference between zinc contents of flours from five regions. The values of magnesium content were below that of 85 mg/100 g reported in grated cassava (Adeniji et al., 2007). Fermented cassava flours contained minerals such as P, Mg, Fe, Zn and Ca. it is therefore, a source of micronutrients. The significant variations in mineral contents of flours could be explained by fermentation process. Indeed, fermentation of cassava is conducted by microorganisms that need micronutrients for their activity. In addition, the multidimensional analysis of variance (MANOVA) done on the physicochemical characteristics showed a significant difference between these flours. Then, cassava fermented flours were statistically different. For the future usages (breadmaking and *placali* preparation), it is therefore necessary to choose flours with right characteristics (i.e., high starch and protein contents). According to the protein content of fermented flours, it was observed that all the values recorded were very low. Then, the fermented flours with high starch content will be chosen for valorisation in breadmaking and *placali* preparation. For this purpose, it was observed that the fermented flours, which have the highest starch content, were from *Belier*, *Lôh-djiboua*, *Guemon* and *Nawa* regions. Because of their high starch contents, these flours can be used for valorisation in the expected usages. For the following experiments, the flour from *Belier* region was the chosen one. This flour has been used in *placali* preparation. The MANOVA table from hedonic appreciation scores showed that all the *placali* samples were statistically different. The sensory evaluation test indicated a significant difference between the *placali* samples in terms of visual appearance, odour, taste, texture and overall appreciation. Sample F28 recorded high scores for the above parameters. This sample F28 was then, highly appreciated. In the contrary, the sample F50 that recorded low scores for visual appearance, odour, taste, texture and overall appreciation was the least appreciated one. Thus, p*lacali* prepared from fermented cassava flour was diversely appreciated. It is a clear indication that reconstitution proportion (flour to water ratio) affects all the hedonic appreciations evaluated. The texture of fermented dough is one of the main parameters that guide consumer choice (Oduro-Yeboah et al., 2007). In this study, sample F28 and sample F33 have the most appreciated texture. Then, these *placali* samples, which differed only on the taste, were the most appreciated ones. Consumers prefer sample F28 and sample F33 as *placali* with desired characteristics according to their food habits. Therefore, *placali* prepared from fermented cassava flour were highly appreciated when reconstitution proportion (flour to water ratio) was within 1:3.5 and 1:3.

The *cassava/wheat bread* samples (Baguettes and round loaf breads) prepared using 15% of fermented flour and 85% of wheat flour were submitted to sensory analysis. The sensory evaluation test indicated a significant difference between the bread samples in terms of visual appearance, odour, taste, texture and overall appreciation. Despite the significant difference between the breads, all the scores were high. It is a clear indication that the assessors appreciate highly the breads prepared from 15% of fermented cassava flour as partial substitute of wheat. It is not the case of the breads from the first formulation (30% of fermented cassava flour), which are not allowed to sensory evaluation because of their poor quality. It can be deduce that the proportional composition of flours affects the quality of breads. Thus, fermented cassava flour is a nonwheat source that could be used as partial substitute (15%) to wheat flour in breadmaking. Shittu et al. (2007) reported the proportion values of cassava flour as a partial substitute for wheat, between 10 and 20% to obtain bread with desired characteristics. In this study, the proportion of substitution is between this range. The incorporation of cassava flour in breadmaking seems to be benefits for developing countries (Touko et al., 2007; Ohimain, 2014). Therefore, the use of fermented cassava flour in breadmaking could help developing countries reducing their wheat importation, saving money and raising their production of cassava roots. Fermented cassava flour has been used successfully in breadmaking and *placali* preparation. Then, it is a means of diversifying cassava utilization form.

Conclusion

The study has shown that fermented cassava flour is an energizing food, rich in carbohydrate with starch as main constituent. Its protein, ash, lipid and total sugar contents were low. The low pH value, moisture and cyanide contents are an indication of a good shelf life and safety. Fermented cassava flour is a source of micronutrients. It has been used successfully in *placali* preparation and breadmaking. In terms of sensory analysis, the hedonic evaluation indicated that the composite cassava/wheat bread obtained with 15% of fermented cassava flour as partial substitute of wheat is highly appreciated by consumers. *Placali* prepared from fermented cassava flour was also appreciated when reconstitution proportion (flour to water ratio) was within 1:3.5 and 1:3. Fermented cassava flour can be used to diversify cassava utilization form. The use of fermented cassava flour in breadmaking and *placali* preparation could generate more income and improve food security in developing countries.

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