Vol. 19(4), pp. 48-57, April 2025
DOI: 10.5897/AJMR2024.9767
Article Number: 59953F673174
ISSN: 1996-0808

http://www.academicjournals.org/AJMR

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African Journal of Microbiology Research

Full Length Research Paper

Assessing the effects of two fermentation methods on the physico-chemical, microbiological and sensory properties of "placali" prepared from three improved cassava varieties

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Received 13 August, 2024; Accepted 28 January, 2025.

Placali is a paste made by fermenting a mixture of cassava chips after they have been ground and pressed. However, the organoleptic quality of placali differs depending on the producer. This fluctuation in quality is not only due to the variety of cassava but also, and above all, because of the type of fermentation process used. The aim of this study is to evaluate the impact of two types of ferments on the quality of placali obtained from improved cassava varieties, in addition to determining the physico-chemical, microbiological, and sensory properties. The results showed that placali samples prepared with dried ferment (FS) exhibited the best characteristics. Indeed, fresh FS placali pastes were less acidic, with a low hydrocyanic acid content. In addition, FS paste had a larger dry matter content, which would increase its shelf life. In comparison to 1 kg of boiled ferment from 10 kg of cassava chips, 0.5 kg of dried ferment from 10 kg of cassava chips demonstrated the great fermentative potential of the dried ferment. According to sensory investigation, the FS placali was the most well-liked since it had the least ferment scent and was less acidic. To standardize and enhance placali quality in Côte d'Ivoire, it would be valuable to support female placali producers in using this ferment.

Key words: Placali, ferment, physico-chemical, microbiological, sensory properties, cassava varieties.

INTRODUCTION

Cassava (*Manihot esculenta* Crantz) is a significant staple crop in the humid tropical zone, providing a key food source for over 800 million people in tropical regions, with around 500 million relying solely on it in

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Figure 1. Roots of the three cassava varieties: a) Bocou 2, b) 15(127)21, c) 15(239)29.

Africa (Kouassi et al., 2015). Cassava production has routinely exceeded cereal growth rates (Vernier et al., 2018). According to Perrin (2015), the global cassava harvest topped 283 million tons in 2013, as recorded by the FAO. Cassava is one of the most important food crops in Côte d'Ivoire, with national production exceeding 5.4 million tons in 2017. With this huge output, Côte d'Ivoire is the world's 17th largest cassava grower (Kanga and Aka, 2018) and Africa's third largest, after only Nigeria and Ghana.

Cassava roots and leaves are widely consumed in African countries as economical sources of energy (Berry, 1993). Cassava, therefore, plays an important role in addressing food insecurity problems in drought-affected regions, because not only does it have a relatively high biological efficiency in food energy production, but it also has the ability to thrive in adverse weather conditions (Burns et al., 2010). Despite its potential, cassava faces storage problems due to its perishability and hydrocyanic acid content. Numerous initiatives have been undertaken to solve these problems, including the introduction of new varieties that are resistant to disease and sometimes fortified with nutrients. Some of these new varieties, such as Bocou 2, 15(239)29, and 15(127)21, have colored flesh, abundant in bioavailable beta carotene (provitamin A), and stand as a significant asset for improving the nutritional status of the population. These new varieties also have a short shelf life. A variety of cassava processing techniques have been developed to ensure a long shelf life, resulting in the development of a wide range of products, including: Lafun (made by soaking cassava roots for three days), Abacha (cassava chips that are popular as a snack in south-eastern Nigeria) (Balagopalan, 2002), attiéké (cassava semolina), Dumby (a common traditional food in Liberia) (Raheem and Chukwuma, 2001); attoukpou (cooked fermented cassava cake); Agbelima (a popular fermented food in Ghana and Côte d'Ivoire); Kokondé (made with fermented cassava chips); and placali (fermented and cooked cassava paste) (Amoa-Awua et al., 1996).

In Côte d'Ivoire, attiéké and placali are the main cassava-based dishes (Kakou, 2000). According to Kanga and Aka (2018), it is highly prized by the Ivorian population due to its physical and financial accessibility. Placali is a paste made by grinding and pressing cassava chips, which are then fermented. However, the organoleptic quality of placali differs per producer. This variation in quality is caused not only by the variety of cassava but also, and most importantly, by the fermenting procedure utilized. Given the diversity of cassava types growing in Côte d'Ivoire, it would be helpful to popularize them, particularly those with colored flesh, for the production of placali. The primary goal of this study is to determine how two distinct fermentation procedures affect the physicochemical, microbiological, and sensory aspects of placali derived from improved cassava varieties. The overall goal of this study is to assess the impact of two types of ferments on the quality of placali produced from enhanced cassava varieties. This involved the following objectives: identifying the physicochemical characteristics of cassava pastes, listing the presumptive microorganisms involved in the fermentation process, and conducting sensory analysis of the two placali prepared with the ferments.

MATERIALS AND METHODS

Source of material used

The plant material for the study included three cassava cultivars with colorful flesh: Bocou 2, 15(127)21, and 15(239)29 (Figure 1). Samples were collected at maturity, 12 months after planting, from an experimental plot in the Sakiari location, Yamoussoukro, with latitude (7°1'43.97"N) and longitude (5°15'54.50"W). The experimental plots were cleaned before planting and for the first three months. No chemicals or biological treatments were used. Cassava roots were harvested and transported to the CNRA Technological Research Station in Bingerville for processing. A 15 kg sample of cassava roots was taken from each cultivar to be processed into placali.

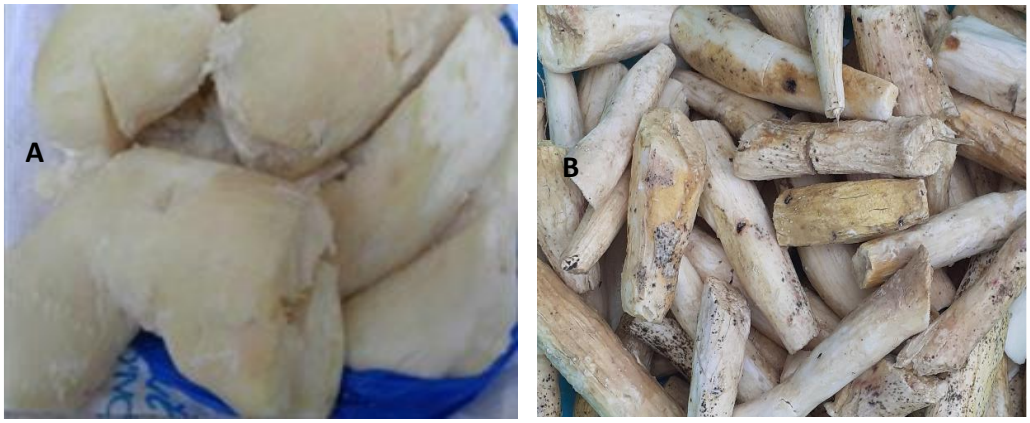

Figure 2. Boiled ferment (A) and dried ferment (B).

Preparation of ferments

Two preparation methods were used to obtain the ferments used for fermenting cassava paste; boiling and drying.

Boiled ferment (FB)

Cassava roots were peeled, washed with potable water and cut into pieces. The pieces were then cooked in boiling water (100°C) for 10 min. After cooking, the roots were air-cooled, then stored in a jute bag for 72 h.

Dried ferment (FS)

Cassava pieces were soaked for 24 h in cassava pressed juice obtained during previous fermentations. After 24 h, the cassava pieces were sun-dried for 2 to 3 days. The two types of are as shown in Figure 2.

Making placali paste

Placali was prepared following several stages. The cassava roots were peeled and cut manually with stainless steel knives. The pieces were then washed three times with tap water. For each variety, 10 kg of cassava pieces were used for grinding. Before grinding, 0.5 kg of previously prepared dried fermented was added to the different batches for the preparation of placali (FS) and 1 kg of boiled ferment for the preparation of placali (FB). The whole batch (pieces + ferment) was progressively introduced into an electric grinder to obtain a homogeneous paste. After grinding, the various pastes were packed in jute sacks and left to ferment in large baskets under heavyweight pressure for 16 to 18 h. After fermentation, the paste was pressed for 2 h to extract the water, using a manual press (Figure 3). The paste samples obtained were used to determine physico-chemical and then microbiological characteristics, and to prepare the placali.

Physico-chemical characteristics of cassava pastes

Determination of hydrogen potential (pH)

The pH of the pieces and pastes was determined according to the AOAC (1990) method. 1 g of pieces or paste was dissolved in 10 ml of sterile distilled water. Each suspension was homogenized by shaking for 15 min at ambient temperature before being centrifuged at 3,000 rpm for 20 min (Nahita Centrifuge Model 2640/8 Spain). The pH of the sample was determined by dipping an electrode from a calibrated pH meter (Vivosun, USA) into the supernatant recovered after centrifugation.

Determination of moisture and dry matter content

The samples' moisture and dry matter content were determined using the AOAC method (1990). Each dough sample weighed 5 g in tared porcelain crucibles using a balance (Ohaus USA). The crucible and sample were heated in a vented oven to 105°C until a consistent mass was achieved.

At the end of the drying, the crucible was removed from the oven and placed in a desiccator to cool before being weighed again using the same balance. Moisture and dry matter contents were calculated using the following mathematical relationships:

$$TH = (M1 - M2)/PE\ x\ 100 \quad (1)$$

$$TMS\ (\%)\ =\ 100\ (\%) - TH \quad (2)$$

where TH: moisture content, expressed as a percentage (%); TMS: dry matter content, expressed in percent (%); M1: mass of crucible and sample before drying, expressed in grams (g); M2: mass of crucible assembly and sample after drying and cooling, expressed in grams (g); PE: mass of fresh sample (g).

Determination of ash content

Ash content was determined using the AOAC (2000) method. Five g of pulp or pieces were weighed using a precision balance (OHAUS, USA). These samples were calcined in an oxidizing muffle furnace (Volca V 50) at 550°C for 24 h until residue was obtained. The ash content was determined according to the following formula:

$$TC\ (\%)\ =\ [(m1 - m0)/m]\ x\ 100 \quad (3)$$

where TC: ash content, expressed as a percentage (%); m0: mass of crucible empty (g); m1: mass of crucible + calcined sample (g); m: mass of sample (g).

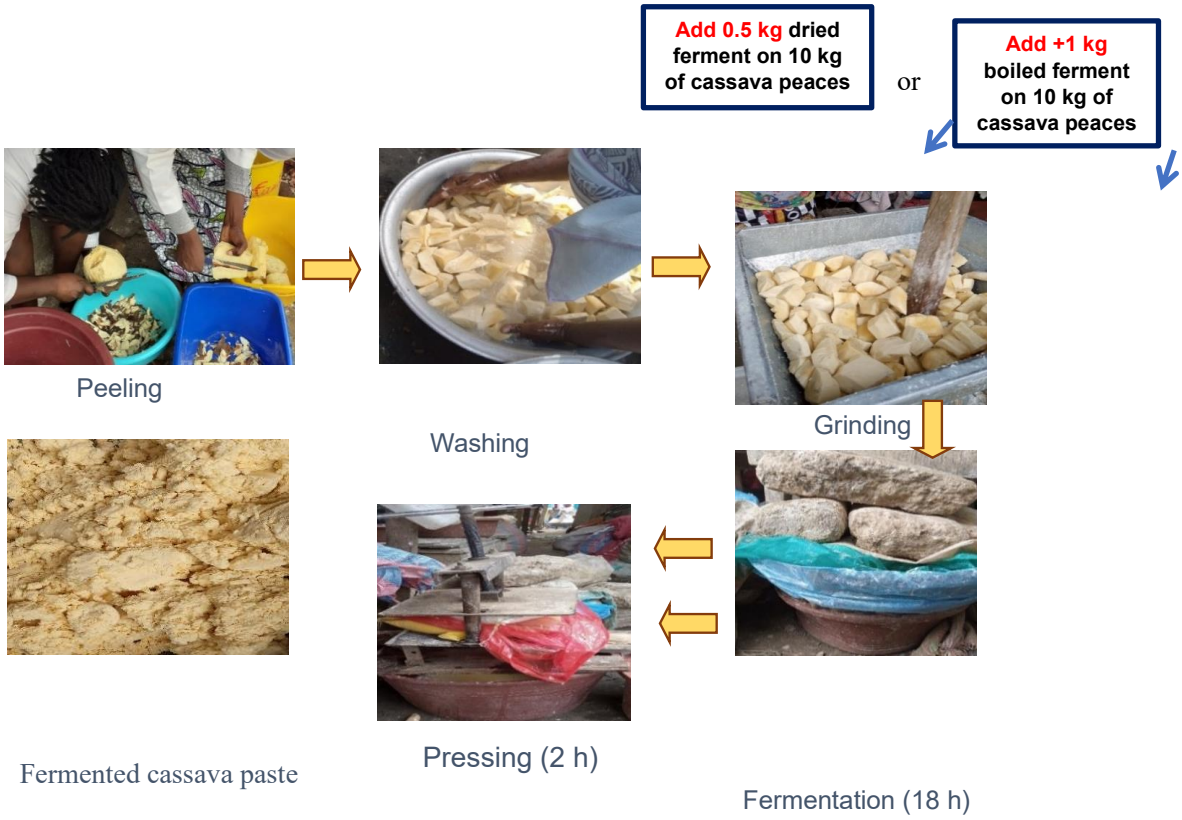

Figure 3. Steps for making fermented cassava paste.

Hydrogen cyanide determination

The method used to determine hydrocyanic acid content is that described by LIEBIG (1971) and improved by DENIGES (1979), based on the principle of releasing hydrocyanic acid (HCN) by heating, recovering it in soda and then quantifying it by silver titration. 20 g of cassava paste were diluted and macerated in 200 mL of distilled water for 3 h. The mixture was distilled to a volume of 100 mL; the distillate was collected in 20 mL of 0.1 N sodium hydroxide solution. Eight mL of 5% potassium iodide (KI) were added to the distillate (100 mL), then a solution of silver nitrate ($AgNO_3$ at 0.02 N) was added dropwise until opalescence appeared.

The hydrocyanic acid content was determined by the equation:

1 mL $AgNO_3$ (0.02 N) is equivalent to 1.02 mg HCN (4)

Determination of sugars

To extract the sugars, 5 g of cassava paste were placed in a 200 mL flask and diluted in 50 mL of distilled water heated to 60°C. The mixture was stirred until cool and filtered through filter paper. The mixture was stirred until cool and filtered through filter paper. The filtrate was made up to 100 mL using a volumetric flask.

Reducing sugars were assessed by the method described by Bernfeld (1955). 0.1 mL of water-soluble sugar extract was taken from a test tube and made up with 0.1 mL of distilled water. 0.2 mL of 3 to 5 dinitrosalicylic acid (DNS) was added, then placed in a boiling water bath for 5 min. After cooling, 3.6 mL distilled water was added to the mixture to determine the optical density (O.D.) with a spectrophotometer reading at 540 nm wavelength. The amount of reducing sugars in each sample was obtained from the D-Glucose standard range carried out under the same experimental conditions.

Carotenoid assay

Carotenoids and vitamin A were assayed using the Rougereau (1981) method, which involves extracting carotenoids and vitamin A using an organic solvent, then quantifying them using a spectrophotometer.

Two grams of cassava paste were diluted in 5 mL ethanol at 96°C and 0.2 mL hydroquinone solution (20 g in 100 mL ethanol 96°C). After 1 minute of rotary mixing, 10 ml of hexane were added. The homogeneous mixture was put into buckets and centrifuged at 3000 rpm for 20 min. The supernatant was collected in a 250 mL flask and shielded from light with aluminum foil. To assay the carotenoid content, 2 ml of supernatant were collected in a quartz cuvette for spectrophotometer reading of optical density at 450 nm against a blank consisting of hexane-alcohol solution (2V/1V).

A standard range of β-carotene was also prepared from a stock solution of 1.25.10-3 mg/mL, as shown in Table 1. The carotenoid content of the samples was obtained by projection on the standard curve.

Microbiological analysis of cassava pastes

Microbiological analyses were carried out on cassava pastes after grinding.

Table 1. β-carotene standard range.

No. of tube	0	1	2	3	4	5
B-carotene (ml)	0.0	0.4	0.8	1.2	1.6	2.0
Hexane/Alcohol (ml)	2.0	1.6	1.2	0.8	0.4	0.0

Preparation of solution

The stock solution and decimal dilutions were prepared in accordance with ISO 6887-1: 1999. To this end, 10 g of fermented paste of each cassava variety was added to 90 mL of peptone-buffered water under aseptic conditions. The mixture was stirred for 5 min, and then used as the stock solution and 10^{-1} dilution. Next, 1 mL of the stock suspension was added to 9 mL of salt tryptone. Following the same technique, successive dilutions were made up to dilution 10^{-5}. All dilutions were performed aseptically. Only dilutions 10^{-4} and 10^{-5} were seeded, with two trials per dilution. Identification and enumeration of cassava paste microorganisms was carried out as follows: Nutrient agar (NG) was used for *Bacillus* enumeration; Sabouraud agar with Chloramphenicol was used for yeast and mold enumeration; Lactic acid bacteria were counted on MRS (Man Rogosa Sharp) agar.

Inoculation was carried out by spreading 0.1 ml of the decimal dilutions considered (10^{-4} and 10^{-5}) on the surface of the agar previously poured into Petri dishes. The seeded Petri dishes were incubated at 37°C for 48 h to 72 h in the oven. After incubation, colonies characteristic of *Bacillus* species (large, creamy, translucent, serrated, with regular or irregular edges), yeast (white, creamy, ovoid, smooth colonies without extension at margins) and mold (hairy colonies with extension at margins, producing various colored pigments) were counted on plates containing 15 to 150 colonies. The whitish and dwarfed colonies, smooth, domed or spread out with regular contours and isolated, presumptive characteristics of lactic acid bacteria, were counted on plates containing 15 to 150 colonies.

Expression of microbiological results

After incubation, colonies were counted to determine the number of colony-forming units per gram of dough (CFU/g). The results, expressed in CFU/g, were obtained in accordance with NF ISO 4833, using the formula:

$$N = (\sum C) / (dV \times (n1 + 0.1n2)) \quad (5)$$

where N = number of colonies; $\sum C$ = total sum of colonies counted on the retained plates; V = volume of inoculum; d = first dilution considered; n1 = number of plates at the first dilution considered; n2 = number of boxes at the second dilution considered.

Sensory analysis of placali samples

Placali preparation

For the preparation of placali, 100 g of fermented cassava paste (Figure 2) was diluted in 150 ml of cold water. The resulting solution was filtered through a sieve to remove fibers and other solid particles. The filtrate in a pot was then brought to the boil while stirring with a wooden spatula until thickened. As soon as the paste was homogeneous, it was covered and left to cook over low heat for 10 min. The paste was removed from the heat when a thick, translucent mass was obtained.

Sensory analysis of placali

The tests were carried out at the CNRA Technological Research Station (Bingerville). After cooking the cassava pastes of each variety, the placali samples were packed in a sealed jar and taken to a room for tasting. The trained panel comprised 15 people. Two tests were carried out: a hedonic test and a descriptive test. Six sensory attributes were selected for the placali. These were color, elasticity, finger firmness, aroma (ferment), sour taste and sweetness. The tasting sheet consisted of an initial hedonic rating table, in which the consumer was asked to rate his or her appreciation, and a second table in which he or she was asked to rate the intensity of the attribute. The ratings ranged from 1 to 10, with 1 corresponding to "very bad" and 10 to "very good", making it possible to compare placali from the four cassava varieties.

Statistical analysis

SAS 9.4. software was used for statistical processing of physico-chemical and microbiological data to determine significant differences ($P<0.05$) between product means. XLSAT 2020.3.1 software was used for statistical analysis of sensory data. This tool was used to determine the discriminating characteristics of placali at $p < 0.1$. ANOVA was carried out to determine significant differences respectively between varieties and then between types of ferment. A Tukey test was used to make multiple comparisons between products at the 5% threshold.

RESULTS

Physico-chemical characteristics of fermented cassava pastes

Figure 4A shows the dry matter content of cassava pastes fermented with dried ferment (FS) and boiled ferment (FB), respectively. FS paste had higher dry matter content (49.7-47.07%) than FB paste (45.27-46.92%). Regardless of variety, statistical analysis revealed a significant difference in dry matter content between FS and FB paste. Like dry matter content, the pH of cassava pastes varied according to the type of ferment used (Figure 4B). The pH of FS cassava pastes (ranging from 4.88 to 4.96) was significantly higher than that of FB pastes (3.43 to 3.79). These lower pH values for FB pastes reflect a more pronounced acidity and would demonstrate the ability of the boiled ferment to acidify the cassava paste.

The hydrocyanic acid content of FS and FB pastes ranged from 0.65 to 2.27 mg per 100 g MF (Figure 4C). The hydrocyanic acid content of FS pasta from the three varieties is lower (0.65-0.75 mg per 100 g MF) than that of FB paste (1.69-2.29 mg per 100 g MF). Figure 4D

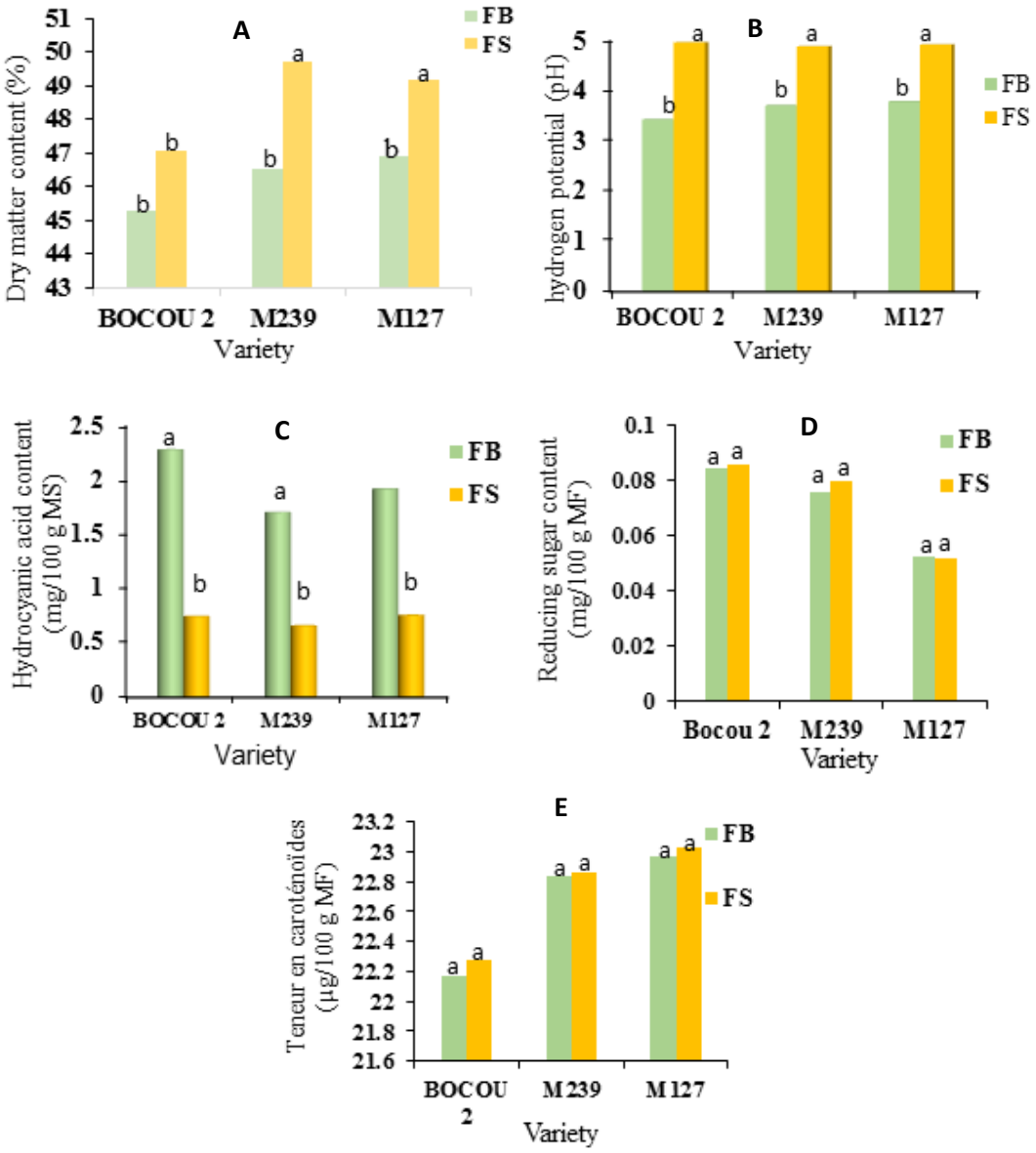

Figure 4. (A) Dry matter content of of pastes FS and FB. (B) Potential hydrogen of pastes FS and FB. (C) Hydrocyanic acid content of FS and FB pastes. (D) Reducing sugar content of FS and FB pastes. (E) Carotenoid content of FB and FS pastes.

shows the amount of reducing sugars present in fermented cassava paste. The results show that there is no significant difference between the sugar content of FS and FB paste from the three varieties. The carotenoid content of FS and FB paste ranged from 22.17 to 23.03 µg per 100 g MF (Figure 4E). Statistical analysis reveals a significant difference in the carotenoid content of FS and FB paste from the Bocou 2 variety.

Microbiological analysis of fermented paste

Table 2 shows that four groups of microbes (lactic acid bacteria, *Bacillus* species, yeasts and molds) were found in all cassava paste samples. However, the loads of these microorganisms differed from one sample to another. For example, lactic acid bacteria were more abundant in FB paste than in FS paste. *Bacillus* bacteria, yeasts and molds were also present in greater numbers in FS paste.

Sensory characteristics of placali samples

Discriminating descriptors

Of the 6 descriptors measured, sour taste, odor and color

Table 2. Microorganisms present in fermented pasta samples.

Fermented cassava paste	Lactic acid bacteria	*Bacillus*	Yeast-Mold
Bocou 2 FB	$2.96\times10^{8}\pm 0.01$	$8.55\times10^{6}\pm 0.02$	$2.55\times10^{5}\pm 0.01$
Bocou 2 FS	$1.97\times10^{6}\pm 0.85$	$7.81\times10^{7}\pm 0.63$	$4.43\times10^{7}\pm 1.63$
M 239 FB	$2.02\times10^{8}\pm 0.02$	$7.82\times10^{6}\pm 0.01$	$3.5\times10^{5}\pm 0.3$
M 239 FS	$1.7\times10^{6}\pm 0.28$	$6.94\times 10^{7}\pm 0.76$	$4.94\times10^{7}\pm 1.25$
M 127 FB	$1.87\times10^{8}\pm 0.01$	$6.57\times10^{6}\pm 0.41$	$3.30\times10^{5}\pm 0.10$
M 127 FS	$1.55\times10^{6}\pm 0.28$	$7.16\times10^{7}\pm 0.23$	$4.65\times10^{7}\pm 1.17$

Table 3. Discriminating power by Placali descriptor.

Descriptors	Value test	p-values
Sour taste	9.570	0.000
Ferment odor	8.445	0.000
Color	3.845	0.000
Finger firmness	0.636	0.262
Elasticity	-2.501	0.994
Sweet taste	-2.573	0.995

Table 4. Average descriptors for placali samples.

Variable	Odor	Sour taste	Sweet taste	Color	Finger firmness	Elasticity
15(239)29_FB	5.850	6.150	1.600	5.100	6.900	5.750
15(127)21_FB	6.150	6.500	1.650	5.800	7.000	5.850
Bocou_FB	5.800	6.300	1.550	4.300	6.900	5.750
15(127)21_FS	3.200	1.750	1.600	4.750	6.450	5.850
15(239)29_FS	2.350	1.900	1.550	6.050	6.900	5.850
Bocou_FS	2.200	1.800	1.500	4.800	7.650	5.950

are the most discriminating for placali ($p<0.1$) as shown in Table 3. They enable us to better characterize placali. These observations show that sour taste and ferment aroma are the descriptors that would enable panelists to distinguish the samples and make their choice.

Average descriptors

Table 4 shows the descriptor averages for each type of placali. Averages significantly above the overall average are shown in bold font, while averages significantly below the overall average for a descriptor are shown in normal. Whatever the variety, placalis obtained with FB ferment had a more pronounced odor (5.80 to 6.15) and sourness (6.15 to 6.50) than Placali obtained from FS, with odor and color intensities hovering around 4.3 and 5.8 respectively. In terms of color, 15(239)29_FS had a more pronounced coloration than Bocou FB. In terms of "Finger firmness", only Bocou FS was significantly firmer (7.65) than the other placali.

Principal component analysis

Principal component analysis (PCA) using Pearson's test ($p < 0.05$) was used to study and visualize the sensory diversity of the different placali (Figure 5). PCA was used to represent 79% of the total attribute variance. The F1 axis, representing 58% of the total variance, contrasts the attributes of sourness and ferment odor with those of overall appreciation of the placali. This observation reflects a decrease in sourness and an increase in odor. The F2 axis, which accounts for 21% of total variance, expresses color and firmness to the finger.

Furthermore, the distribution of samples along F1 and F2 clearly separates placali fermented with FB from those fermented with FS. The FB placali were more sour, with a more pronounced ferment odor, and therefore less appreciated. In contrast, FS placali were more elastic and

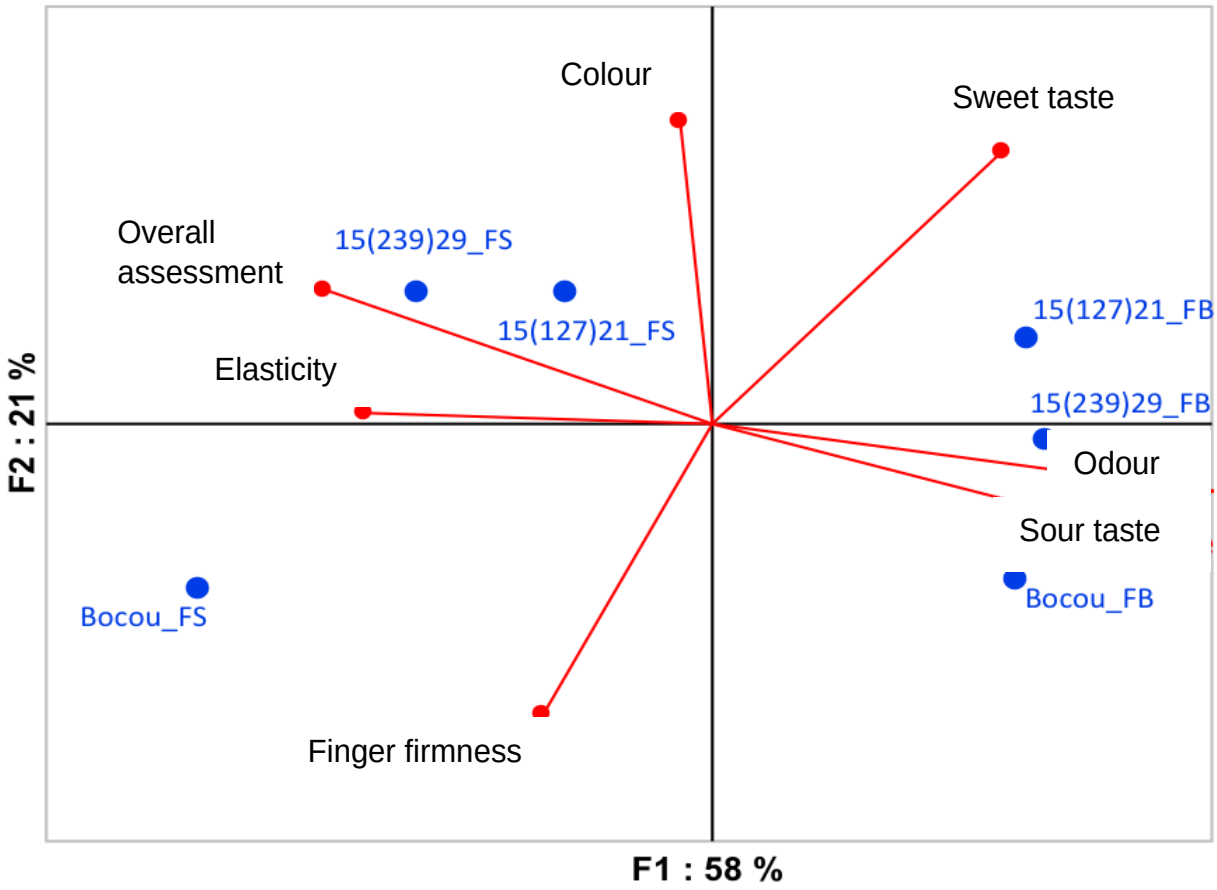

Figure 5. Biplot illustrating the effect of ferment type on placali sensory quality.

Table 5. Effect of ferment type on placali sensory attributes.

Variable	Color	Odor	Elasticity	Finger firmness	Sour taste	Sweet taste	Overall assessment
R^2	0.004	0.727	0.003	0.001	0.764	0.001	0.766
F	0.421	314.508	0.339	0.084	381.371	0.112	385.515
Pr > F	0.517	< 0.0001	0.561	0.773	< 0.0001	0.739	< 0.0001
Ferment type	0.421 0.517	314.508 < 0.0001	0.339 0.561	0.084 0.773	381.371 < 0.0001	0.112 0.739	385.515 < 0.0001

less sour.

Additionally, analysis of variance (Table 5) showed that the type of ferment used had a significant effect on the sensory attributes of placali at the 5% threshold. Indeed, over 79% of the variance in odor, sour taste, and overall acceptability was explained by the type of ferment used. However, the type of ferment had no effect on the coloration, elasticity, and sweetness of placali. On the other hand, the FS ferment produced a significantly more appreciated placali with a less sour taste and less pronounced odor, compared with the FB ferment (Table 6).

Overall assessment of placali samples

The acceptability test revealed that there was a significant difference between placali from dried ferment (FS) and that from boiled ferment (FB). Placali (FS), with an overall score of between 7.6 and 7.8, was highly appreciated for its less perceptible fermented odor and slightly acidic taste. The placali (FB), on the other hand, was less appreciated, with an overall score of between 4.9 and 5.2, as it was very sour with a pronounced fermented aroma.

Table 6. Comparison of overall acceptability scores for placali samples.

Variable	Overall score
15(239)29_FB	5,200
15(127)21_FB	5,000
Bocou_FB	4,900
15(127)21_FS	7,800
15(239)29_FS	7,750
Bocou_FS	7,600

DISCUSSION

In this study, three varieties of cassava with colored flesh were used for placali production with two types of ferment (boiled and dried ferment) to determine their influence on placali quality. With regard to physicochemical characteristics, the results showed that the dry matter content of FS paste was higher (47.07-49.7%) than that of FB paste (45.27-46.92%). The values obtained in this study are higher than those of Donat et al. (2018) (28-36.5%). The relatively high dry matter content of the paste is thought to be due to the fermented paste production process. After fermentation, the fermented paste undergoes a pressing stage. According to Oti et al. (2010), this step reduces the moisture content, thus increasing the dry matter content. Of all the varieties, Bocou 2, an improved variety bio-fortified with β-carotene, recorded the lowest dry matter content (28%). This value is close to that found in the work of Donat et al. (2018) in the Democratic Republic of Congo on the dry matter content of yellow pulp cassava clones. After measuring the dry matter content of yellow cassava, these authors obtained a value between 28 and 36.5%. This low dry matter content of Bocou 2 could be explained by its β-carotene content. Indeed, according to Moorthy et al. (1990), cited by Njenga et al. (2014), tubers rich in carotenoids would have a low dry matter content. The pH study showed that FB paste was more acidic than FS paste. This acidity in the dough samples is due to the production of organic acids by lactic acid bacteria. Additionally, the slightly higher pH values of FS paste could be explained by the presence of fewer lactic acid bacteria in the dried ferment. It should also be noted that the presence of organic acids in cassava paste is responsible for the placali's acidic taste (Toka et al., 2008).

The hydrocyanic acid content is responsible for the bitterness and toxicity of cassava (Toka et al., 2008). The transformation of pieces into fermented paste considerably reduces the quantity of hydrocyanic acid. This reduction is partly due to the washing and grinding of cassava chips (Amoa-Awua et al., 1996) and partly to the degradation of hydrocyanic acid by the microorganisms present in the ferment. Indeed, it has already been demonstrated that certain microorganisms such as yeasts, bacteria, and fungi are capable of degrading linamarin through the synthesis of linamarase (Ikediobi and Onyike, 1982). Linamarase is a β-glucosidase that catalyzes the degradation of cyanogenic compounds. It should be noted that FS paste contains very low levels of hydrocyanic acid (0.65-0.75 mg per 100 g MF). The addition of dried ferment for cassava fermentation should improve the hydrolysis performance of linamarin and lotaustralin, thereby reducing the toxicity of the resulting foodstuffs.

With regard to sugar content, our study showed that FS and FB paste contain low levels of sugar. Cassava is considered an energy food due to its high starch content (Barampama, 1992). The presence of reducing sugar is therefore due to the breakdown of starch into glucose by the microorganisms contained in the two types of ferments. Carotenoid content is virtually identical (22-23 µg/100 g) in both types of placali. The cassava varieties used in this study thus prove to be potential sources of vitamin A. Consumption of these colored-fleshed varieties in the form of placali could help solve the problems associated with vitamin A deficiency.

The results of the microbiological analysis showed the presence of lactic acid bacteria, bacteria of the *Bacillus* spp., yeasts, and molds in both FS and FB pastes with different loadings. Work carried out by Djouldé (2005) in Cameroon revealed the presence of lactic acid bacteria, yeasts, and molds in fermented cassava pastes. The high load of lactic acid bacteria and *Bacillus* found in FB paste is due to their high numbers in the boiled ferment, and to the presence of sugars, water, and the anaerobic conditions created by the cassava paste. All these factors favor the proliferation of these microorganisms. As for the FS ferment, solar drying conditions facilitate the proliferation of yeasts and molds.

The results of the overall assessment of the different placali showed that placali prepared with dried ferment were very much appreciated because of the ferment aroma, which was less perceptible, and the slightly acidic and sweet taste. It would therefore be interesting to recommend the use of dried ferment and colored cassava varieties for the preparation of placali.

Conclusion

This study showed that the two types of ferment used have significant effects on the physicochemical and sensory characteristics of placali. Placali samples prepared with dried ferment (FS) exhibited the best characteristics. Indeed, fresh FS placali pastes were less acidic, with a low hydrocyanic acid content. In addition, the dry matter content of FS paste was higher, which would extend its shelf life. Also, the dried ferment demonstrated a high fermentative power, as 0.5 kg of dried ferment fermented 10 kg of cassava chips,

compared with 1 kg of boiled ferment for 10 kg of cassava. Sensory analysis showed that the FS placali was the most appreciated, as it was less acidic with a slight ferment aroma. It would therefore be beneficial to encourage female placali producers to use this ferment to standardize and improve placali quality in Côte d'Ivoire.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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