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Chemical and Sensory Characteristics of two Types of Cassava Pulp during their Processing into *Bedecouman*

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ABSTRACT

This study was undertaken to analyze and compare the chemical composition and sensory characteristics of *bedecouman* made from two cassava pulps at various stages of its preparation. The fermented cassava dough contained 54-56.7% moisture, 2.06-1.98% proteins, 0.20% lipids, 1.15-1.1% ash, and 23.86-23.65% starch for the white and yellow pulp respectively. The investigations showed respectively 68.35-69.3% moisture, 1.04-1.01% proteins, 0.28-3.9% starch and 0.17-0.2% lipids for the white and the yellow *bedecouman*. The end product had a mean hydrocyanic acid content of 52.12 and 55 mg HCN/kg for the white and yellow pulp, respectively and for the fermented cassava dough 155.62 and 135 mg HCN/ kg. High rating was given to the flavor for the white pulp (8.92), then homogeneity (uniformity of the appearance) 8.16 and 7.50 for the white and yellow pulp, respectively. There was a significant difference between the types of pulp especially for color and flavor. Boiling was more efficient than natural fermentation in reducing the HCN.

Keywords: boiling, cyanidric acid, fermentation, proximate composition

INTRODUCTION

The present work was undertaken to characterize and compare the chemical composition and organoleptic characteristics of *bedecouman* made from two types of cassava, white pulp and yellow pulp, and to help understand the loss of cyanogens during cassava processing.

Cassava (*Manihot esculenta* Crantz) is the most important tropical root crop and in many African countries. The crop contributes significantly to the diets of over 800 million people, with per capita consumption averaging 102 kg a year. In some areas of Africa it makes up over 50 percent of the daily diets of the people (FAO 2001). Cassava is grown mainly by smallholder farmers with limited resources for its starchy roots which are a major source of dietary energy, and widely consumed in warm tropical areas (Assanvo *et al*. 2006; Akely *et al.* 2010). Cassava ranks as the world's fifth most important foot crop after maize, rice, wheat and potato and fourth in the developing countries, after rice, maize and wheat (FAO 2009). Cassava provides income, employment and food security for more than 500 million people in Africa, Asia and South America (Pluknett *et al*. 2001). In 2008, around 232.95 million tons of cassava was produced. More than half of that amount was produced in Africa (54%), 30% in Asia and only 16% in Latin America and the Caribbean. About 2/3 of production is in Nigeria. Cassava is an all-season food crop in several African countries (and particularly in Côte d'Ivoire), Asia and Latin America (Assanvo *et al*. 2006; Abodjo Kakou *et al*. 2010).

Every year, Côte d'Ivoire produces about 1.9 million metric tones of cassava making it the second largest food crop after the yam which is another important root with an estimated yield of 3 million tons in 2002 (Akely *et al.* 2010; Djeni *et al*. 2011). The traditionally producing areas of cassava in Côte d'Ivoire are Abidjan (southern region), Bouaké (central region), Man (western region) and Daloa (central western region). Most of the cassava produced is used as a food product by people for whom roots are the major source of calories.

Fig. 1 Loaves of *bedecouman* from cassava yellow and white pulp.

When cassava roots are not processed soon after harvesting, their use is limited because of their deterioration only a few days after harvesting. The losses are also due to the relatively high amount of compounds such as cyanogenic glycosides whose hydrolysis (Onwuka and Ogbogou 2007) leads to the release of toxic hydrocyanic acids that can cause diseases such as tropical ataxic neuropathy and endemic goiter (Koffi-Nevry *et al*. 2007). Over 90% of the cassava processed in Africa is used for human nutrition as fermented products (Koffi-Nevry *et al*. 2007; Djeni *et al*. 2011). Traditionally, cassava is processed before consumption. Processing is necessary for several reasons. First, it serves as a means for removing or reducing the potentially toxic cyanogenic glucosides present in fresh cassava. Second, it serves as a means of preservation. Third, processing yields products that have different characteristics, and creates a variety of cassava based food.

There are several varieties of cassava, but they can be classified into two groups: sweet and bitter varieties (Assanvo *et al*. 2006; Obeta *et al*. 2007). Cassava is processed into various end-products in Côte d'Ivoire. Some sweet or bitter varieties show two different colors: white and yellow

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pulp. Depending on the variety, cassava is either associated with banana in order to make *foutou* or processed into products of fermented dough. In Côte d'Ivoire, sweet white pulp cassava may be consumed directly mainly through dishes like *foutou*, *foufou*, *akessi* or braised roots. The bitter white pulp varieties are traditionally processed into a wide range of foods with different local names such as *attiéké*, *placali*, *attoukpou*, *konkondé*, *bedecouman* (Assanvo *et al.* 2006; Koffi-Nevry *et al.* 2007, 2008; Akely *et al.* 2010; Djeni *et al.* 2011). Therefore, white pulp cassava is more consumed in Côte d'Ivoire than the yellow pulp cassava, which is less known to the population. One of the dishes is the *bedecouman*, a speciality of the southern people of Cote d'Ivoire.

In Côte d'Ivoire, many studies have been conducted on cassava-based products such as *attieke* using the white varieties (Coulin *et al.* 1991; Yao *et al.* 2006; Akely *et al.* 2010; Djeni *et al.* 2011). *Bedecouman* (also called *bessike*) is obtained through cooking, pounding and shaping a pre-fermented cassava dough. The *bedecouman* comes in the shape of a loaf about 10 to 15 cm long, packed in *Tomatococcus danielli* leaves are commonly called leaves of *attiéké*. People eat it together with a stew. It can also be kept at room temperature for 4 days and consumed within those days without any further preparation (Koffi-Nevry *et al.* 2008). These authors studied the proximate and microbiological composition of a cassava based product consumed in Côte d'Ivoire namely *bedecouman*, made from a variety of white cassava pulp from Bonoua. Very few studies have incorporated the yellow pulp in the production of cassava-based food. To our knowledge, there is no publication in Côte d'Ivoire about the use of the yellow pulp cassava.

MATERIALS AND METHODS

Collection of cassava tubers

Freshly harvested roots from two local varieties of sweet cassava called Bonoua (white pulp and yellow pulp) were collected from a farm in Adaou, a village located in the vicinity of Aboisso (South Eastern region of Côte d'Ivoire). All cassava roots, about 30 cm long and 10 cm in diameter, were processed in the laboratory of Food Biochemistry and Tropical Products Technology, at the University of Abobo-Adjamé, Abidjan, Côte d'Ivoire. The traditional inoculum (leaven) used is made from fermented cassava; the cassava was previously boiled, kept in a synthetic fiber bag and left to ferment at room temperature (30 ± 2°C) for 4 days.

Processing of *bedecouman*

In the production of *bedecouman*, 20 kg of the two types of Bonoua cassava roots were processed according to the method described by Koffi-Nevry *et al.* (2008). The whole roots were peeled, cut into pieces, washed in clean water and ground in a cassava grinder. The ground pulp represents the unfermented (fresh) dough. Fermentation is not spontaneous but initiated by the addition of 8% (w/w) of a traditional inoculum as previously described. The inoculum was carefully added to the fresh dough in order to obtain a homogeneous mixture. The mixture was then packed into a corn bag and allowed to ferment for 24 h at room temperature (30 ± 2°C). The product obtained at the end of this step is the fermented dough. At the end of the fermentation, the water and the starch are squeezed out of the fermented dough. The solid residue obtained was then sieved in order to eliminate the fibres. The processing of the sieved product into *bedecouman* includes 2 boiling steps: initial and final boiling steps. The sieved product was packed into small quantities (about 150 g), in *Tomatococcus danielli* leaves commonly called "*attiéké* leaves", and immediately boiled for 15 to 25 min. The boiled product is pounded in a mortar, re-packed in *attiéké* leaves and boiled again for 30 to 60 min. The final product was pounded again, shaped into loaves and packed one more time in *T. danielli* leaves. Depending on the variety of cassava used, the final product called *bedecouman* can be white or yellow.

Of note, before the last packing, the leaves were disinfected by boiling them for 1 h. The unfermented and fermented doughs, the one-time boiled and final products were subsequently analyzed for their proximate composition, cyanide and organoleptic characteristics.

Chemical analysis

The two varieties of cassava were analyzed as unfermented, fermented and cooked forms. The following composition characteristics were determined in the samples. Dried weight was determined by drying 5 g samples to constant weigh (AOAC 1990) in an infrared dessicator (Mettler Lp16). The moisture content was determined by calculating the difference in mass before and after desiccation (105 ± 1°C). Proteins were determined by the Kjeldahl method by multiplying the total nitrogen by 6.25 (AOAC 1990), and the fat through a Soxhlet extraction method (Unid Tecator, System HT2 1045, Sweden). The ash fraction was obtained by incinerating the organic matter at 550°C (AOAC 1990). The pH of samples was measured using a calibrated glass electrode pH-meter (Hanna Instrument HI 9318). 10 g of each sample were dispersed in 100 mL of distilled water. The dispersion was allowed to stand for 30 min. Acidity was determined according to the French Industrial Standard Authority (AFNOR 2002). Total reducing sugar content was determined on a dry matter basis, according to the dinitrosalicilic acid (DNSA) method described by Kimaryo *et al.* (2000). Hydrocyanic acid content was determined using silver nitrate volumetric analyses (AOAC 1990; Oboh *et al.* 2002) for cooked, fermented and raw cassava dough, and the starch content was obtained through the difference in absorbance at 450 nm according to the method of B.I.P.E.A (1976). All determinations were made in triplicate, the results expressed on dry weight basis, and mean values calculated.

Sensory evaluation

The sensory evaluation panel was composed of 15 people who were not familiar with *bedecouman*. They rated the flavor, aroma, color, consistency (texture) and homogeneity on a scale of 1 through 10 where 1 = extremely bad and 10 = extremely good. The evaluation was performed in two sessions.

Statistical analysis

The experiments were carried out twice. Since there was no significant difference between the two experiments, the results were pooled and averaged. The experiments were laid out in a completely randomized block design. Regarding the sensory evaluation experiments, mean values of organoleptic characteristics were compared. In order to determine which means (for flavor, aroma, color, consistency and homogeneity) for dry mass and percentage of extraction were significantly different from others, differences between means were assessed by Duncan's multiple range test at $\alpha = 0.05$ (Musyimi *et al.* 2008).

RESULTS AND DISCUSSION

Fig. 1 shows an image of the 2 types of *bedecouman* obtained from the white and yellow pulp. The final product is creamy white or yellow. The results from the chemical analysis are shown in **Tables 1** and **2**. From these tables, it appears that the proximate composition of the cassava dough was affected during processing into *bedecouman*. The chemical composition was different between and within the types of pulp, except for the ash, the lipid and moisture contents. The titratable acidity of the fermented dough increased from 90-95 to 115-110 meq/100 g rapidly, lowering the pH to below 5.0. The acidity decreased during cooking and in the final product to 77.5 meq/100 g in the 2 types of cassava pulp studied. However, there was no discernable trend in the pH values (about 4.5) of the fermented cassava dough during processing into *bedecouman*. The decrease in pH during fermentation was due to the production of organic acids by lactic acid bacteria (Abodjo Kakou *et al.* 2010; Oguntoyinbo and Dodd 2010).

The result of the analysis of the fresh and the fermented

Table 1 Proximate composition and hydrogen cyanide of the unfermented and fermented dough from 2 varieties of cassava (White and Yellow Bonoua).

Composition	White pulp		Yellow pulp	
(g/100 g dw)	Fresh dough	Fermented dough	Fresh dough	Fermented dough
Dry matter	32.7 ± 0.03	46 ± 0.002	34.3 ± 0.01	43.3 ± 0.03
Moisture	57.3 ± 0.03	54 ± 0.002	65.7 ± 0.01	56.7 ± 0.03
Protein	0.95 ± 0.02	2.06 ± 0.05	0.96 ± 0.03	1.98 ± 0.05
Lipid	0.20 ± 0.10	0.20 ± 0.08	0.23 ± 0.10	0.21 ± 0.10
Starch	25.60 ± 0.7	23.86 ± 0.62	25.45 ± 0.8	23.65 ± 2.5
Reducing sugar	2.70 ± 0.06	1.88 ± 0.03	3.01 ± 0.05	2.13 ± 0.06
Ash	1.1 ± 0.005	1.2 ± 0.03	0.90 ± 0.005	1.1 ± 0.03
pH	6.17 ± 0.5	4.38 ± 0.7	6.24 ± 0.5	4.50 ± 0.5
Acidity (meq/100 g)	90 ± 5	115 ± 5.59	95 ± 3.53	110 ±7.07
HCN (mg/kg)	253.12 ± 27	155. ± 22.01	236.37± 18.9	135 ± 3.53

means ± standard deviation

Table 2 Proximate composition of white and yellow Bonoua fermented cassava dough during the processing into *bedecouman*.

Composition	White pulp		Yellow pulp	
(g/100 g dw)	Initial boiling	Final boiling	Initial boiling	Final boiling (*bedecouman*)
Dry matter	40.8 ± 0.002	31.65 ± 0.005	38. 5 ± 0.005	30.7 ± 0.002
Moisture	59.2 ± 0.002	68.35 ± 0.005	61.5 ± 0.005	69.3 ± 0.002
Protein	1.26 ± 0.08	1.04 ± 0.07	1.08 ± 0.02	1.01 ± 0.05
Lipid	0.18 ± 0.10	0.17 ± 0.10	0.2 ± 0.05	0.2 ± 0.10
Starch	13.09 ± 0.71	0.28 ± 0.02	15.45 ± 0.35	3.9 ± 0.051
Reducing sugar	1.5 ± 0.03	1.38 ± 0.05	1.01 ± 0.06	1.01 ± 0.06
Ash	0.60 ± 0.005	0.60 ± 005	0.3 ± 0.05	0.3 ± 0.05
pH	4.52 ± 0.1	4.56 ± 0.5	4.53 ± 0.5	4.58 ± 0.50
Acidity (meq/100 g)	105 ± 3.53	77.5 ± 2.5	105.3 ± 53	77.5 ± 2.50
HCN (mg/kg)	95.62 ± 3.11	52.12 ± 3.53	90.37 ± 5	55 ± 3.50

means ± standard deviation

cassava pulp revealed that there was an increase in dry matter content of the fermented cassava dough (46%; 43.3%) when compared to the unfermented one (32.7%; 34.3%) for the white and yellow cassava pulp, respectively (**Table 1**), and a decrease during the cooking process (31.65%, 30.7%) (**Table 2**). The values of dry matter obtained in the two cassava pulps analyzed agreed with those of FAO (2001), which indicated that cassava roots contain 30-40% dry matter. The values recorded for the dry matter indicate that *bedecouman* contains a high percentage of water, making it a perishable product. The cooking process increased the moisture content to about 69%. This value is higher than that from *gari* (Ketiku *et al*. 2003), *attieké* and *attoukpou* (another fermented cassava product) (Koffi-Nevry *et al.* 2007). Mould, yeast and bacteria can grow readily on *bedecouman* when left at room temperature. The higher moisture content of *bedecouman* can be explained by the final process of cassava transformation. There is a drying step in *attieke* and *gari* production. *Attoukpou* is obtained by steamed cooking as *attieke* while the final steps in *bedecouman* production are boiling.

The result of the analysis revealed an increase in the protein content of the fermented cassava dough (2.06 and 1.98% for white and yellow *bedecouman*) when compared to the unfermented dough (0.95 and 0.96% for white and yellow *bedecouman*). Then, a decrease was observed during the cooking process. The increase of protein content of the fermented cassava dough could be attributed to the possible secretion of some extracellular enzymes (proteins) such as amylase, linamarase and cellulase (Oboh and Akindahunsi 2003) into the cassava mash by fermenting organisms, as well as an increase in the growth and proliferation of the fungi/bacterial complex in the form of single cell proteins (Oboh *et al*. 2002). The decrease during the boiling process could be explained by the hydrolysis of the enzymes (proteins).

There was a more pronounced decrease in starch content from the initial boiling (13.09%-15.45%) to the final boiling (0.28-3.9%) for the white and yellow pulps respectively when compared to the fresh cassava dough (25%). A slight decrease of reducing sugar (0.80%) was noted in the fermented dough and after the two cooking steps. The decrease in starch could be attributed to the ability of the microorganisms in the inoculum (ferment) to hydrolyze the starch into glucose (reducing sugar), which ultimately will be used by the same organisms as a source of carbon to synthesize fungi/bacterial biomass with a high protein content (Oboh *et al*. 2002). Ampe *et al*. (2001) showed that reducing sugars are widely used during fermentation as a source of carbon by lactic acid bacteria. There was no discernable trend of the ash content between the unfermented dough (1.1-0.9%) and the fermented one (1.2%, 1.1%) from the two types of cassava pulp studied. A decrease was observed after the two boiling steps (0.6 and 0.3%) for the white and the yellow Bonoua cassava pulp, respectively. The values for *bebecouman* in this study (0.6 and 0.3%) were similar to that obtained by Yao *et al*. (2006), which was 0.4% for *attieke.*

Cassava roots usually have a high concentration of cyanogenic glucosides. The white pulp contains more cyanide (253.12 mg/kg) than the yellow pulp (236.37 mg/kg). The fresh cassava dough contains more cyanide than the fermented one and the *bedecouman*. Cassava is often classified as "bitter or sweet" according to the amount of cyanide present. The normal range of cyanoglucoside content in fresh roots is from 15-400 mg HCN/kg fresh weight (Obeta *et al*. 2007) but occasionally varieties with very low HCN content of 10 mg/kg or very high HCN content of 2000 mg/kg.

The high hydrocyanic acid (HCN) contents in the fresh and the fermented cassava dough make them unsafe and unsuitable for human consumption (Ebuehi *et al*. 2005). Cooking the fermented cassava dough during processing into *bedecouman* reduced the cyanide content down to 52.12-55 mg/kg from 253.12-236.37 mg/kg for the unfermented and 155.62-135 mg/kg for the fermented dough for the white and the yellow cassava pulp, respectively. The highest reduction occurred during the second cooking step. The HCN results attest that during cassava processing, part of the HCN is eliminated during fermentation due to its solubility in water (Muchnik and Vinck 1984). The HCN values obtained in the *bedecouman* are above the recommended FAO/WHO (1992) safe limit set at 10 mg HCN/kg and still slightly above the threshold of tolerance, which is 50 mg/kg. The toxicity is not eliminated probably because the fermentation process was too short and the product was

Table 3 White and yellow *bedecouman* organoleptic characteristics.

Characteristics	White *bedecouman*	Yellow *bedecouman*
Colour	6.42 ± 1.2 a	3.91 ± 2.3 b
Consistency	7 ± 2.7 a	6.42 ± 1.7 a
Homogeneity	8.16 ± 2 a	7.50 ± 2.3 a
Flavour	8.92 ± 1 a	6 ± 1.6 b
Aroma	6.33 ± 9 a	6.50 ± 2.6 a

Means with the same letter superscript on the same line are not significantly different ($p<0.05$)
means ± standard deviation

wrapped in *T. danielli* leaves before cooking.

Therefore, *bedecouman* from the 2 types of cassava pulp could be considered unsafe in terms of cyanide poisoning.

The high values of HCN recorded in this study could be explained by the duration of the fermentation which was only 1 day, too short to release a large amount of HCN. About 38-42% percent of the cyanogens in fresh cassava dough were lost after fermentation, but a substantial proportion remained in the dough. In addition, more HCN was eliminated during the cooking steps. At the end of those cooking steps, a substantial proportion (76-79%) of the cyanogens was again eliminated. Therefore, cooking was more efficient than natural fermentation in reducing cyanide. The level of HCN in the *bedecouman* could probably be lower if the fermentation and cooking steps were longer. Onwuka and Ogbogu (2007) reported that fermenting cassava for 2 or more days is sufficient to detoxify the HCN. Koffi-Nevry *et al.* (2007) reported values of 11.7 mg HCN/kg for *attoukpou* after 3 days of fermentation. Muchnik and Vinck (1984) showed that HCN which is volatile and soluble in water, could be removed during washing, fermentation, drying and cooking. Indeed, Muchnik and Vinck (1984) indicated that after the hydrolysis of starch, the decrease in pH due to the presence of lactic acid bacteria facilitates the breakdown of cyanogenic glucoside in the presence of the limanarase enzyme in cyanide which drains out during cooking. In this study, the pH of the fermented dough (pH 4.5) facilitates the release of the HCN during cooking.

The sensory test results are shown in **Table 3**. This sets out the rating given by testers using the scale described earlier. A high rating was given to flavor of the white pulp (8.92) than homogeneity, 8.16 and 7.50 for the white and the yellow pulp, respectively. The highest color rating was given to the white pulp (6.42 vs 3.91) while the highest aroma rating was given to the yellow cassava pulp. There was, however, no significant difference ($p>0.05$) in the aroma, color, flavor, and overall acceptability within the white *bedecouman*, but there was a significant difference ($p<0.05$) between the types of pulp, especially for color and flavor. Fermentation is responsible for product stability, better flavor and aroma, and for the reduction of HCN (Nout and Sarkar 1999). The organic acids produced during fermentation include lactic, acetic, propanoic, and butanoic acids, among others. These are believed to contribute to the characteristic flavor of fermented cassava products.

CONCLUSION

The processing of cassava into *bedecouman* significantly affected the chemical properties of the 2 types of cassava pulp samples analysed. Fermentation is an important process in the preparation of many cassava products in Africa, although a limited number of techniques are used. Cooking was more efficient than the natural fermentation in reducing the cyanide. The study of the traditional production of *bedecouman* was intended to help understand the loss of cyanogens during cassava processing.

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