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Fermented Cassava dough: A Prerequisite for the Technological, Biochemical and Microbiological Properties of Attiéké in Côte d'Ivoire

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ABSTRACT: Attiéké and fermented cassava dough are two cassava derivatives linked by the same transformation process. Fermented dough is obtained after spontaneous fermentation of the pulp over 2 to 3 days, with the addition of inoculum on cassava. Fermentation of dough for attiéké occupy an important role in the availability of fast sugars, mineral salts and cyanide, and in granulation. The dough becomes more acid under the action of Yeasts, Molds, Bacillus and mainly Lactobacillus. Dehydrated by pressing, it is generally characterized by a pH around 4.5, a humidity of around 52% for a reducing sugar content of around 1%. The aspect of the fermented dough that precedes attiéké depends on the factors and conditions involved in fermentation, the force of pressing and the hygiene of operations. However, the traditional processes and properties of attiéké have been assessed without prior studying the technological and biochemical properties of fermented cassava dough.

KEYWORDS: Fermented dough, attiéké, technological, biochemical and microbiological properties.

1 INTRODUCTION

Cassava (*Manihot esculenta* Crantz) is a tuber with a wide range of applications, and its culinary diversity in Africa makes it an integral part of strategies to combat hunger. The importance of cassava motivates increased cultivation and processing, making it a priority for food security (Terry, 1986; Favier, 1977; Thresh, 2002). Around 314.8 millions tons of cassava were grown in Africa, representing about 60% of global production (Food and Agriculture Organization (FAO, 2021)). Cassava is produced and consumed in the sub-Saharan part of West Africa as porridge, gari, bread, cooked dough, attiéké, etc. Some cassava derivatives are still only consumed locally, but attiéké, steamed semolina, which originated in Côte d'Ivoire and is highly prized by its inhabitants, is gaining in popularity. Annual production of fresh attiéké is estimated at 40,000 tons (Egnankou, 2020). Annual consumption is estimated at 100 kg per capita per year. Around 5,818 tons of attiéké, mostly from the Bouaké wholesale market, were supplied to Malian markets, a figure estimated in 2015 by a survey report from Mali's Observatory of agricultural market, (FIRCA, 2018). Demand for cassava byproducts is also increasing in the countries of the sub-region, boosting exports, particularly of dough and attiéké (Mendez del Villar *et al.,* 2017). Fermented cassava doughs for human consumption are generally prepared as jellied doughs, but mainly as attiéké (Guira, 2013). More than 4,000 tons of cassava and derivatives reportedly entered Burkina Faso from Côte d'Ivoire in 2013 and 2014 (Perrin *et al.,* 2015). According to operators, the quantities exported to Burkina would be greater than those sent to Mali (informal estimates of demand from Burkina give more than 20,000 tons per year). Bags of pulp are collected in the town of Bouake and surrounding localities in the department. At the loading point, the bags of fermented cassava dough are stacked on top of each other and can last several weeks, with or without shelter, before being exported (Barussaud & Kouassi, 2019). Marketed fermented cassava dough is of interest for placali primary consumption, but for use in producing attiéké, in remote, deficit regions. This trade contributes to improving the incomes of women producers and combating food shortages in demand countries.

The quality of attiéké depends on the physiological and sanitary state of the tubers, the microbiological state of the ferment, the proper conduct of operations and hygiene conditions, all of which contribute to the quality of the dough. However, processing into fermented cassava dough is achieved artisanally by traditional experience, rather than on the basis of theoretical and rational knowledge (Krabi *et al.,* 2015; Zoumenou *et al.,* 1998). This reality bears witness to the fact that production quality is not maintained constant in an artisanal unit. From one region to another, as well as between producers in the same area, attiéké granules vary in grain size, texture, sourness and color. As a result, attiéké production gives rise to variations in quality, and the characteristics of the dough to be fermented need to be elucidated. First and foremost, attiéké is a traditional skill from the south of Côte d'Ivoire, described as the original attiéké, for which urban pressure and the illiteracy of women producers have considerably affected its nature.

2 General Information On Cassava

2.1 Origin And Botany

Cassava (*Manihot esculenta* Crantz), a tropical species native to America, has its center of distribution in the south-western Amazon basin. It is believed to be one of the oldest cultivated crops. Cassava was introduced to West Africa by the Portuguese in the second half of the 16th century, then spread throughout Africa and South Asia during the 18th and 19th centuries, favored by colonial authorities (Perrin *et al.,* 2015). In Côte d'Ivoire, it was cultivated in the 19th century by immigrant Akan populations (Abouré and Alladjan) who introduced it there from southern Ghana (Amani *et al.,* 2007).

Cassava is a semi-woody shrubby annual or biennial plant that can reach a height of 2 to 3 meters in cultivation, even 3 or 5 meters without being harvested (Favier, 1977). The cassava plant has alternate leaves, with an odd number of leaf lobes, varying from 3 to 7 lobes. The leaves are 10 to 20 cm wide, deeply palmatipartite, dark green above and glaucous below (Vernier *et al.,* 2018).The flowers, in clusters, appear in the same inflorescence at the branching point of the stem. The unisexual male and female flowers are pink, purple, yellowish or greenish, and lack a corolla. Fruits are dehiscent capsules, bursting noisily when ripe. The well-developed root system consists of tracing roots up to 1 m long. The main roots measure 5 to 10 cm in diameter and tend to tuberize. They are generally arranged in bundles that can reach 20 to 50 cm in length at harvest time.

2.2 Cultural Requirements

Cassava is an undemanding crop that adapts to different types of soil and climate in the intercrops, giving relatively satisfactory yields. Cassava has been adopted voluntarily by Africans because of its specific characteristics, which include ease of cultivation in shifting cultivation systems, flexibility of harvesting, resistance to attack and resistance to drought (Carter *et al.,* 1994). It is less demanding and more resistant than certain cereals, notably maize and rice. As a result, cassava cultivation may require few chemical inputs. Production costs can generally be low, thanks to self-production of planting material and affordable labor. Nevertheless, cassava grows well in fairly light, well-drained soil consisting of around 40-60% sand, 30-50% silt and 15-25% clay without excessive moisture (Perrin *et al.,* 2015). It can be grown in all unimodal or bimodal rainy seasons, from 600 mm to over 4000 mm of rainfall per year. The best yields are recorded for rainfall of between 1200 mm and 1800 mm per year, with a minimum temperature of 12°C and a maximum growth rate of between 25 and 29°C (Mémento de l'agronome, 2006).

2.3 Composition Of Cassava

Cassava is a high-energy food, essentially made up of carbohydrates. It contains sugars (maltose, fructose, glucose and sucrose) and around 80-90% starch. The cassava root is not very rich in indigestible carbohydrates, is fairly rich in ascorbic acid and is very low in all other nutrients: lipids, mineral salts, vitamins and especially proteins (Favier, 1977). The average composition of cassava pulp in Côte d'Ivoire is shown in Table 1.

Table 1. Nutrient composition of 100g fresh cassava pulp

Water	**60 mg**				
Carbohydrates	**38 g**	**Sodium**	**14 mg**	**Vitamin A**	**13 IU**
Dietary fiber	**1,8 g**	**Potassium**	**271 mg**	**Vitamin D**	**0 IU**
Sugars	**1,7 g**	**Magnesium**	**21 mg**	**Vitamin B12**	**0 µg**
Protein	**1,4 g**	**Calcium**	**16 mg**	**Vitamin C**	**20,6 mg**
Fats	**0,3 g**	**Iron**	**0,3 mg**	**Vitamin B6**	**0,1 mg**
Calories	**159 calories**				

Source: Agence Nationale d'Appui au Développement Rural, (2017)

2.4 CYANIDE COMPOSITION

Cassava roots and leaves contain cyanogenic compounds, with linamarin (93-96%) being the most abundant and 4-7% lotaustralin (Sylvestre &Arraudeau, 1983). Leaves, stems and root bark contain more cyanogenic glucosides than the peeled root. These compounds are hydrolyzed to produce hydrogen cyanide (HCN), a substance that is toxic to hemoglobin and the nervous system and an endocrine disruptor of the thyroid gland (Delange & Ahluwalia, 1985). When the plant's cells are damaged, these cyanogenetic compounds break down under the effect of enzymes, releasing hydrogen cyanide. This breakdown takes place in two stages, starting with enzymatic hydrolysis of the glucoside by endogenous cassava enzymes, which releases the carbohydrates on the one hand and cyanohydrin on the other, followed by purely chemical dissociation of the cyanohydrin to produce hydrogen cyanide and acetone (White *et al.,* 1994).

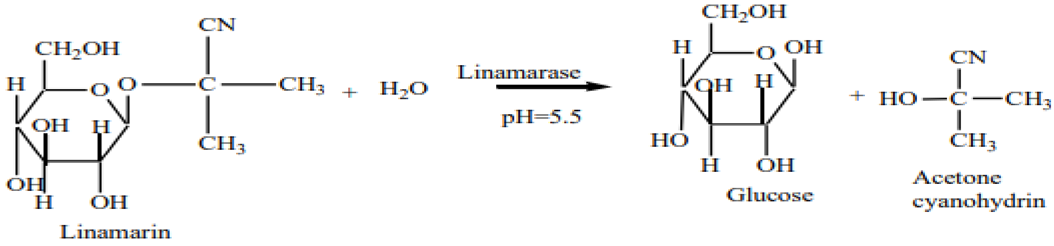

Fig. 1. Ddiagram of hydrogen cyanide synthesis

Source: Fomunyam et al., (1985); White et al., (1994)

The decomposition of cyanohydrin, an unstable molecule into hydrogen cyanide and acetone, is done either spontaneously at a pH above 5 or a temperature above 35°C, or under the effect of another enzyme as Hydroxynitrile Lyase (Brauman *et al.,* 1995; Delange & Ahluwalia, 1985; Raimbault *et al.,* 1990). This standard is limited to 10mg/ Kg for cassava flour following the Commission régulation (EU) 2022/1364, 2022. The standard value for cooking of fermented cassava is between 0,001 et 0,85 mg/kg (FAO/OMS, 2019). Hydrogen cyanide is known to be soluble in water and vanishes into the air when the temperature is above 26°C in conditions of retting, fermentation, drying, cooking on cassava.

According to the content of hydrogen cyanide, cassava compound three forms, bitter with more 100mg/kg of pulp, moderately bitter (between 50 and 100mg/kg), and sweet (under 50 mg/kg). In dry areas with less than 1200 mm of rainfall per year, bitter taste cassava varieties can develop, unlike the more demanding sweet taste cassava (Mémento de l'agronome, 2006).

3 BY-PRODUCTS OF FERMENTED CASSAVA

The by-products of cassava processing are numerous and differ from one region to another. The elimination of cyanogenetic compounds is a major concern in all processing processes for both human and animal consumption. Cassava by-products are obtained by cooking, drying and fermenting, all of them reduce cyanide levels. Traditional African dishes include gari, attiéké, placali, attoukpou, cassava sticks (miondo, bobolo, mintoumba from Cameroon and chikwangue from Congo) and agbelima. Miondo, bobolo and mintoumba are all cassava sticks made by the same process. Depending on how it is packaged, and the ingredients added (salt, pepper oil for mintoumba), this cassava stick changes its name (Kouakou *et al.,* 2015). Peeled and washed, the tubers are soaked in water for 3 to 5 days to soften them. This soaking of cassava is called retting. Once retted, the central fiber is removed and the dough obtained by grinding is pressed, wrapped in banana leaves or similar and then boiled. Agbelima also comes in the form of a jelly dough in Nigeria and Benin, where the cassava is ground, pressed and then fermented (Mante *et al.,* 2003). Gari is a long-life dry semolina made by fermenting grated cassava dough over 2 to 3 days. The dough is then pressed, crumbled and sieved to reach the roasting stage (Nago, 1995; Sotomey *et al.,* 2001). Attiéké, a wet semolina made from dough fermented from fresh cassava and a cassava-based leaven fermented in 2 to 3 days. Small quantities of cassava and its leaven are finely ground and then pressed before being sieved and molded (Assanvo *et al.,* 2002; Egbe *et al.,* 1995; Grandval, 2012). The pellets are steamed. Attoukpou is a similar product to attiéké with a compacted appearance. Placali is a jelly-like dough made from fermented cassava dough. In addition to its traditional by-products, the fermented dough is used to produce alcohol, fermented drinks, starch and bread flour (Koko et al., 2014). These processes influence hugely on cyanide's production and elimination of this cyanide with pressing.

4 PACKAGING OF FERMENTED CASSAVA DOUGH

Fermented cassava dough is of vital importance in reducing the toxicity and perishability of fresh cassava, which has a shelf life of only 5 days. Grinding, fermentation and pressing effectively eliminate some of the cyanide and its precursors. What's more, the reduction in humidity could guarantee stability that is conducive to good preservation. Long-term preservation depends on the conditions and quality of operations such as fermentation and pressing. Fermented cassava doughs from Côte d'Ivoire is transported to countries with a low cassava production for processing into attiéké (Guira, 2013; Perrier & Garnier, 2019). This trade raises the question of quality. Indeed these doughs are collected and stored either in the open air, or in bulk or stacked, as shown in figures 2 and 3.

Fig. 2. Bag of loose pulp in the ambient air

Fig. 3. Pulp stacked under tarpaulins

5 History Of The Attiéké Process

The vernacular name "attiéké" is historically linked to the Ebrié people living in the south of Côte d'Ivoire. Before independence, attiéké remained the traditional food for self-consumption by the people of the Ivorian coast. These communities used archaic tools.

5.1 Changes In Production Equipment

Processing equipment has changed from metal rasps to electric grinders and from sheet metal under brick to screw presses (Diarrassouba, 2018). The workload has therefore been reduced but is increasing under the impact of strong demand. The large-scale production of attiéké is forcing the owners of this technique to employ women from the sub-region in addition to family labor. The importance of this emblematic dish of Côte d'Ivoire has motivated public and private authorities to set up small industrial units.

5.2 Process Evolution And Variation

5.2.1 Evolution Of The Process

The processing of cassava into dough and attiéké is ethno cultural. The attiéké of the lagoon peoples was essentially made using braised ferment. The unpeeled cassava was initially placed in embers and then cooled in the open air. This braised cassava then underwent the anaerobic fermentation stage by multiple packaging in jute sacks for 3 days (Gnabro, 2018). The fresh cassava, which is grated, and the ferment were ground with a mortar to obtain a dough, which was pressed to reduce the cyanide content. The amount of oil and leaven used varied from one operator to another. According to (Diop, 1992), for 100 kilograms of cassava, an average of 2 to 4 kilograms of sourdough was needed. After crumbling and forming the grains, the 1-day solar drying and winnowing stages were scrupulously followed. Contemporary attiéké has gained considerable momentum on the Ivorian and international markets. Its production has been encouraged by using of more advanced tools such as the screw press and, above all, the electric grinder.

Today, attiéké is produced by all the peoples of the four corners of Côte d'Ivoire and represents an important source of subsistence income, depending on the marketing circuit. The attiéké production stages follow broadly the same order (peeling, grinding, fermentation, pressing, crumbling, granulation and cooking) for most producers. However, there are notable differences in the method used to design the ferment and the drying time. Organoleptic factors are also designed by producers to enhance taste and color. According to some people in central Côte d'Ivoire, braised ferments give attiéké a good flavor. Others produce attiéké by adding salt during grinding, or discolored palm oil to give it a yellow color. As for the water used, it allowed to wash the dough to reduce the acidity.

5.2.2 Different Designs Of Ferments

In terms of ferment design, the points of difference relate to the type of ferment cooking, the fermentation time, the use of packaging and the fermentation medium. In addition to braised ferment, there are two other trends in cooking of ferment. These are boiled ferment and raw ferment. The survey carried out by Assielou *et al.,* (2018) estimates an adoption rate of 85.3% for boiled ferment compared with 5.3% for braised ferment by several ethnic groups in the south. The Abouré group exceptionally uses raw ferment at 9.4%. This reality on type of ferment is practiced always because of easiness for using boiled ferment and obtaining amount. The optimum fermentation time for raw tubers is 3 days (Tetchi *et al.,* 2012). The duration of fermentation to obtain the ferment varies between 1 and 4 days, but most practice is 2 days and a few hours on the 3rd day.

5.2.3 Variable Drying Times

Solar drying, which firms the grains and preserves them in a few days, is increasingly being abandoned. It is replaced by exposure to the open air in a shed for around thirty minutes. This is largely due to market pressure. Producers also mention the change in color due to dust deposits, climatic disturbances and losses. This form of pre-drying is currently the most common in almost all production areas.

6 Bibliographical Summary

6.1 Microbiological, Biochemical And Organoleptic Study Of Attiéké

Attiéké was studied in several production marketing and experiments places, the information on which is summarized in Table 2. Traditional production is the main knowledge base for Ivorian attiéké and fermented dough. The realities that have evolved with the new production tools and the empirical process design make room for recent studies. The description of the production processes of three attiéké mastery regions and the characterization of their products was carried out by Assanvo *et al.,* (2019). This very rewarding survey covered almost all current aspects of attiéké in these regions (type, granulometry, proportion of production elements, physico-chemical characterization, and sensory evaluation). The physico-chemical characterization confirmed the differences between the types of attiéké and the differentiation criteria.

Table 2. Studies carried out on attieke at different places

Studies at different places	Publications about	References
Traditional production (Survey and analysis)	- Processing method -Microbiological characteristics -Biochemical characteristics of attiéké	Assanvo *et al.*, 2002; Amani *et al.*, 2007; Assanvo *et al.*, 2006, 2019; Djeni *et al.*, 2011; Kouassi *et al.*, 2018; Yéboué *et al.*, 2017
Urban Productions	-Biochemical quality of attiéké -Organoleptic quality of attiéké	Koffi *et al.*, 2004; Amani *et al.*, 2007; Guira, 2013; Krabi *et al.*, 2015
Experimental	-Microbiological and biochemical study of ferments and starter -Microbiological study of experimental attiéké	Kakou *et al.*, 2004, 2017; Kouamé *et al.*, 2017; N'Dédé *et al.*, 2008; Nimaga *et al.*, 2012; Bouatenin *et al.*, 2017; Boli *et al.*, 2020
Commercial	Microbiology and health risks of attiéké on sale	Kpata-konan *et al.*, 2020; Anoman *et al.*, 2018; Akmel *et al*., 2017 ; Yobouet *et al.*, 2016)

The well-made, fiber-free grains add to the traditional product's preferred quality. The average level of cyanide is higher in low-quality commercial attieke called garba (12 mg/100g DM) than in other attiéké (4.41 mg/100g DM). Perceived differences in attiéké quality by (Djeni *et al.,* 2011) confirmed similar biochemical and organoleptic characteristics in the adjoukrou and alladjan production zones compared with the Ebrié zones, where the process is particular. Attiéké is subject to contamination during the production and packaging process, which can affect consumer health through the detection of *Salmonella, Staphylococcus* and toxico-infectious agents (Anoman *et al.,* 2018; Yobouet *et al.,* 2016). Given its short shelf life at room temperature, a new form of attiéké production is envisaged through the dehydration of attiéké and the production of primary grains. The preservable granules produced by Yao *et al.* (2015) show a residual moisture content of 10%, no browning and a stable microbial load. Numerous checks on the sanitary quality of attiéké are carried out to locate the risks of contamination and poisoning at commercial level. Bacillus cereus group was found in 25.2% of attiéké on sale and an average load of vegetative cells and spores were respectively. *B. thuringiensis* (56%) and B. cereus sensu stricto (44%) were identified species (Yobouet *et al.,* 2016). The results showed that the hydrothermal reheating of attiéké by steam at 90°C for at least 15 min reduced B. cereus spores count from in attiéké. A study carried out by Akmel *et al*. (2017) on the microbiological quality of attieke sold in open markets in Cote d'Ivoire estimated that the probability of developing food poisoning due to *C. perfringens* by the consumption this dish was between 1.27% and 2.80%.

6.2 Ferment Characteristics

6.2.1 Type Of Ferments

The crushed pulp is fermented by using a few quantity of fermented cassava. The cassava may be raw, boiled or braised beforehand, then kept in anaerobic conditions for at least 2 to 3 days. The quality of the ferment depends on the initial state, the duration of fermentation adopted by each producer and even by region. Coulin *et al.,* (2006) found that the ferment obtained by partial cooking and fermented after 3 days was the most widely used.

Assielou *et al.,* (2018) reported after a survey in the south of Côte d'Ivoire that whole, uncut cassava was the main ferment used, followed by ferment from cassava cut into small pieces. The same survey estimates that women producers ferment 63% of peeled and boiled whole cassava. The biochemical distinction between boiled, braised and raw type ferments was researched by Kakou *et al.,* (2017). These three types of ferments produced according to the two varieties of bitter and sweet cassava were analyzed every 24 hours for 4 days of fermentation. The pH values gradually decreased from approximately 7.3 to 4.6 in the boiled cassava ferments, respectively for the bitter variety and the sweet variety. In terms of braised cassava ferments, the pH increased from approximately 7.01 to 3.83 for the sweet and bitter varieties. The raw cassava ferment is at a Ph below the other two, 6.08 to 3.75. The Ph of all these ferments after 4 days is between 3.75 and 4.6, a value recognized by the most studies and capable of the acidity of the whole dough to ferment. Regarding titratable acidity, rates increased for boiled and raw cassava ferments from 0.02 to approximate values between 0.08% and 0.12% and at the level of the sweet and bitter variety. In the case of braised cassava ferments, the titrable acidity increased from 0.027 to 0.11% for the sweet variety and by 0.025% to reach 0.82% with the bitter variety.

All types of ferments regardless of the cassava variety recorded a progressive decrease in total and reducing sugars. In terms of sweet varieties, the total sugars of boiled and raw cassava ferments are similar, ranging from 2.7 to 1.2 mg/g and from 2.2 to 0.8 mg/g of material for braised ferments. These total sugars of bitter varieties increased from 1.3 to around 1 mg/g of fresh material in raw and braised ferments and from 2.4 to 1.1 mg/g of material from boiled ferment. With reducing sugars, levels gradually decreased from 1.1 to 0.7 mg/g of material in general on boiled and braised ferments of both sweet and bitter varieties. The raw cassava ferment was distinguished by initially high reducing sugar levels ranging from 1.62 to 0.9 mg/g of fresh material (bitter variety) and from 1.51 to 0.65 mg/g (variety gentle).

6.2.2 RATE OF INCORPORATED FERMENT

The ferment is combined with all the cassava pulp for grinding. Women producers measure the proportions empirically by matching containers. As a result, the mixed proportions remain informal. However, a study by Coulin *et al.,* (2006) and Assanvo *et al.,* (2019) showed that 7-10% of the fresh cassava used to make attiéké was fermented. Further details were provided by Nimaga *et al.,* (2012), who concluded that attiéké of the variety named Yacé made with 10% incorporated ferment and the together fermented for 12 hours was acceptable. It was found that at 10%, lactic bacteria predominate and are responsible for the production of sugars, lactic and acetic acids (Aboua et al., 1990).

Other questions regarding the adequacy between the incorporation rate and the fermentation time were carried out. These are rates of 5, 8,10 and 15% of ferment incorporation for 0,6,12 and 18 hours at a temperature of 35°C (N'Dédé *et al.,* 2008). The dough produced under these conditions showed decreases in pH and total sugars respectively for approximately 4.3 and 0.35 mg/100g of fresh material and an increase in acidity and reducing sugar content respectively of approximately 0.75% and 2.1 g/100g of fresh material after 18 hours of fermentation. In these same studies the highest levels of quantity of lactic acid (482.35 mg/100 g) and acetic acid (236.66 mg/100 g) of fresh material were found at 8% of ferment incorporated after 18 hours of fermentation. The other malic, oxalic, fumaric and citric acids, which are relatively important at each incorporation of ferment, have decreased in quantity at the end of fermentation. Despite these variations in contents, that of ethanol marked a high value of around 25 mg/100g of fresh material at 15% incorporation still at the end of fermentation. The incorporation with 10% of ferment chosen by most authors (Akely *et al.,* 2010; Kouamé *et al.,* 2017; Toka *et al.,* 2018) for studies on attiéké presumes a certain optimization in the traditional process.

6.2.3 MICROBIOLOGICAL STUDY OF THE FERMENT

The ferment, a determining factor in the fermentation of cassava dough, was analyzed in the field. This research, carried out by Assanvo *et al.,* (2002), focused on the microflora of cassava ferment prepared by women producers of Adjoukrou attiéké. The quantitative and qualitative isolation of the major micro-organisms involved in the production of this type of attiéké showed that cassava ferment is a very rich and varied medium in terms of micro-organisms. According to this research, the most frequently encountered germs are lactic acid bacteria (5.7×10^7 cfu/g), yeasts (5.5×10^7 cfu/g), *Bacillus* (38×10^7 cfu/g), total coliforms (3×10^6 cfu/g), enterococci (3×10^6 cfu/g), thermotolerant coliforms (8×10^3 cfu/g) and molds (2×10^6 cfu/g). While lactic bacteria, *Bacillus,* yeasts, enterococci and molds take part in fermentation, coliforms owe their presence to contamination of the ferment by its environment. The ferment ready to be used, has a pH between 5.4 and 6.1 and a temperature of around 30°C.

A microbiological study based on the kinetics of the ferment according to the method of production (raw, boiled, braised) from the varieties (bitter and sweet) was carried out by Kakou *et al.,* (2017). These experiments, which were carried out every 24 hours for 96 hours, showed that the ferments from the sweet variety contained a relatively higher number of lactic acid bacteria (5.83±0,12 log (ufc/g)) and bacillus (6.18±0,42 log (ufc/g)) than those from the bitter cassava (variety. Furthermore, boiled ferments are generally richer in *Bacillus* than raw and braised cassava ferments, regardless of the variety of cassava used. Traditional starters examined from different areas showed significantly similar microbiological loads (*Lactobacillus sp, Bacillus sp,)* but so Yeast (*candida sp*) and Mold in the southern regions of Côte d'Ivoire (Assanvo *et al.,* 2002), in contrast to the central region, which often has a shorter production time (Kouassi *et al.,* 2018).

6.2.4 Microbiological Starter Isolation

The results obtained on artisanal characteristics serve as a microbiological reference for attiéké starter cultures. The question of selecting and producing a starter ready to be use like baker's yeast is of interest to researchers. Yao (2009) explored this idea for the production of a freeze-dried gari lactic acid bacteria starter. For the preparation of attiéké, Krabi *et al.,* (2016) isolated 11 strains of lactic acid bacteria. Of these, 3 strains (*lactobacillus plantarum* 210,140 and 19) showed satisfactory biochemical properties namely rapid acidification, α-amylase production and pH drop below 4 at a temperature of 45°C. These more active strains in fermenting starch contribute significantly to the reduction of cassava cyanide for the production of akyeke, Ghanaian attiéké (Obilie *et al.,* 2004). They are capable of inhibiting the development of pathogenic microbes (Kakou, Boli, *et al.,* 2017; Koffi *et al.,* 2004). Among 42 *Bacillus spp* strains isolated from many production, only 13 Bacillus strains could be used as potential microbial starters in association with lactic acid bacteria for the controlled fermentation of cassava dough (Ehon *et al.,* 2015). These bacillus strains are responsible for production of α-amylase, pectinase, and β- glucosidase improving the organoleptic quality of attiéké by softening and detoxification actions. The work made by Kakou, Ollo, *et al.,* (2017) showed that Bacillus subtilis was the most present to produce various enzymes notably osidases, phosphatases, lipases and proteases, β-glucosidase and α-glucosidase. The optimization of α-amylase 's production searching by Bouatenin *et al.,* (2016) have permit to know importance of *Candida tropicalis* LVX8 which excretes a large amount of α-amylase (171.33 ± 3 EU/mL) in 24 hours. In addition, toxicological studies of starters and attiéké of various origins have detected only traces of Ochratoxine A, down to 0.2 mg/kg in some samples, with no powerful fungal toxins (Kastner *et al.,* 2010).

6.3 Study Of Fermented Cassava Dough

6.3.1 Effect Of Pressing Fermented Cassava Dough

Pressing has an adverse effect on the content of cyanogenic substances. Fermented pulp undergoes pressing and loses some of its water, starch and mineral salts. This operation is generally carried out using a screw press.

Amani *et al.,* (2007) presented the effect of the pressing force of fermented cassava dough on the physico-chemical and sensory qualities of attiéké. In this study, three forces of 0.91 kN, 1.55 kN and 2.58 kN were exerted on 1100g of dough with a water content of 66% for 20 minutes. The water, starch, cyanide and total sugar contents dropped to 46%, 55.5%, 19.5%, and 1.66% respectively. The strong pressure made it possible to obtain dough with characteristics close to the standard for attiéké but is not sufficient for appreciation unlike gari whose pressing is more required. Thus at the level of attiéké, the paste is appreciated in relation to its granulable character which results in semolina of average size and texture always considering a low cyanide level. Semolina with a pressing force of 0.91 kN with rough grains of sizes between 2 and 5 mm in diameter, those of 1.55 kN are characterized by granules of sizes ranging from 0.8 to 2 mm. The pressing force of 2.58 kN resulted in granulation with sizes between 0.4 and 0.8 mm. The force of 1.55 (±0.3) was found to produce at 97% attieke with better physico-chemical qualities and hydrocyanic acid residues of 8mg/ml, lower than the FAO standard recommended to 10mg/ml. However, for the same author, the duration of pressing does not seem to affect the sensory characteristics and the physico-chemical qualities of attiéké.

The use of manual presses without estimation of force and production factors in traditional processes leads to dehydrated dough of different quality. This affects the humidity of the dough and grains, and granulation (Akely *et al.,* 2010). The experiment carried out by this author concludes that cassava paste obtained with inoculum levels of 10 to 12% over 12 to 24 hours of fermentation and at approximately 50–52% of humidity using a press pneumatic is generally favorable to good semolina. The inclination of the semolinizer of 28–31° whose axis in relation to the horizontal also seems more suitable for sizes similar to the reference. The optimal size, which results from these production factors, is estimated to be around 1.25 mm.

6.3.2 Effect Of Temperature

Temperature is a key factor in microbial growth. In the specific case of attiéké, the cassava dough undergoes fermentation after the incorporation of ferment (inoculum) and grinding, which contributes to mixing. This dough is exposed to the ambient air and subjected to pressing and fermentation for 12 to 15 hours (Assanvo *et al.,* 2019).

The effect of temperature on cassava dough (IAC variety) fermented with a 10% incorporated ferment was analyzed by (Amani *et al.,* 2007) under different conditions, namely at 25, 30, 35, 45ºC.The results showed significant differences between the doughs according to the incubation temperatures, but above all that 35ºC seems to be the temperature best suited to microbial growth. This temperature would be conducive to the production of acid, the consumption of sugars and the production of gases during fermentation.

The first analysis is the reduction of the ph to 4 and the increase of the acidity to 1% especially up to extreme temperatures. Most of the physicochemical and microbiological load peaks were observed after 12 hours and at 35°C with 7.8×109 cfu/g of lactic acid bacteria, a pH of 4.2, an acidity of 0.8%, a total sugar content of 0.28g/100g of fresh material, and a reducing sugar content of 0.8 mg/100g.

6.3.3 Study Of Preservation's Fermented Cassava Dough

Numerous studies have been carried out on the long-term quality of attiéké and products derived from the same process. Cassava dough from IAC variety fermented during storage was subjected to a physico-chemical study (Kakou *et al.,* 2004). The washed and unwashed pulps were reduced by pressing to the same humidity at 52% of dry matter and stored in well-closed buckets, at room temperature (30 to 31°C) under cover. The physicochemical analysis of washed and unwashed pulps made it possible to observe the same trends, namely a reduction in the cyanide content (30 to 40 mg/kg), in the pH value (3.82 to 3.9), which stabilizes from the 2nd week and a progressive rise in lactic acid levels. The microbiological analysis of the fermented dough in storage showed the variable and regularly present lactobacillus load during the 10 weeks of storage of the two doughs. This load increased from 6×10^6 germs/g to 4×10^6 for washed dough and from 3×10^6 to 2×10^6 germs/g for unwashed dough.

The aerobic mesophilic germ load initially at 5.9×10^7 germs for washed dough and at 9.6×10^7 germs for unwashed dough decreasing under 10^5 from the 4 th et 5 th week. However, total and thermotolerant coliforms and sulphite-reducing anaerobes disappeared from the first week. This study also revealed the disappearance of yeasts after two weeks and the absence of Staphylococci, molds and Salmonella in the dough during storage (Amajor, 2022; Kouassi et al., 2022)

7 Conclusion

Fermented pressed cassava dough, a intermediate of attiéké, was evaluated with a view of researching the characteristics of attiéké. It is therefore obvious that the quality of the fermented dough influences that of the attiéké, the scale of which has given rise to standards. The present standard on attiéké is an objective achievement in terms of quality control, covering various granulometric, biochemical and microbiological aspects. Fermented cassava dough also deserves special attention in order to achieve quality attiéké and reduce post-harvest losses. Studies carried out on the operational environments of producers or in experimentation constitute a source of interest for the knowledge of data on fermented cassava dough.

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