



Change in Physicochemical Parameters during Traditional Processing of Cassava (*Manihot esculenta* Crantz) into Attiéké (Cassava semolina)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Attiéke has become one of the most consumed foodstuffs and very popular among the populations of Côte d'Ivoire. It is a steamed cassava semolina with a long transformation process involving different fermentation times. Physicochemical and biochemical analyses have shown that attiéké has many nutritional potentials. Physicochemical parameters (pH, lactic and acetic acids, ethanol, starch, sugars (total and reducing) and vitamin C) were analysed during the process of transforming cassava (*Manihot esculenta* C.) into attiéke. Moisture levels ranged from 61.5% (fresh pulp) to 45% (Attiéke). The pH of the fresh cassava (6.1) decreases and reaches 4.7 on the third day of fermentation while that of the attiéké is 5. The acetic (0.48%) and lactic (0.72%) acid contents

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increase and are respectively 2.40 and 3.60% in the attieke. The ethanol content, which does not exist in the fresh pulp, appears during the fermentation and then decreases from 0.86% (24 hours of fermentation) to 2.40 (attieke). The starch content of cassava pulp decreased from 41.1 (fresh pulp) to 39.5% (fresh Attieke). The vitamin C content of the fresh pulp (69mg/100g) decreases and represents only 1 mg/100g in the fresh attieke.

Keywords: Attieke; fermentation; physicochemical properties; cassava; *manihot esculenta*.

1. INTRODUCTION

Cassava (*Manihot esculenta* Crantz) is one of about 199 species of trees, shrubs and herbs constituting the genus *Manihot*, whose distribution extends from northern Argentina to the southern United States of America, sub-Saharan Africa and India, Indonesia and the Philippines. Botanically, cassava is a perennial woody shrub, which can reach 1 to 5 m in height. Its cultivation, mainly for its tuberous, starch-rich roots, is estimated to date back 9,000 years, making it one of the oldest agricultural crops. In Côte d'Ivoire, cassava is a commodity that is produced in about 4/5 of the national territory [1]. It is often grown in association with yam. However, plantations dedicated solely to cassava exist in the production areas [2,3]. Due to the high starch content of the tuberous roots, cassava is an important source of metabolizable energy. Its energy yield per hectare is often very high, and it has the potential to far exceed that of cereals [4]. In some countries, cassava is also grown for its leaves, which can contain up to 25 percent protein on a dry weight basis [5].

Tuberous roots have a short shelf life at room temperature. After harvest, these roots have a maximum shelf life of 3 days after which browning and rotting occur, making them unfit for human consumption [6,7,8]. To limit these losses due to its physiological deterioration 24-48 hours after harvest, cassava root is processed into "placali" [9], gari [10], attoukpou [11] and especially attiéké [12,13,14,15]. Attieke is a food made from steamed cassava semolina, whitish in colour, with a slightly acidic taste [12]. Consumed two to three times a day with meat, fish or raw vegetables, it is the most consumed food in urban centres in Côte d'Ivoire [16,17]. Its popularity is well known in the West African sub-region and even in Europe, where it is exported [12]. It is sold fresh and ready to eat; it is therefore an appropriate cooked dish [18]. Attieke is therefore an important food in the menus of Ivorian populations. It accounts for about 5% of food expenditure and 20.5% of calories in the fresh attiéké ration and represents

the main source of income-generating activity for many people, including those in the coastal region of Abidjan who are known to be major producers and consumers [19]. Annual production is estimated at between 18,965 tonnes and 40,000 tonnes for an annual consumption varying from 28 kg to 30 kg per capita [20,21]. This study aims to establish a database of organoleptic properties and nutritional value useful for national specifications and nutritional advice.

2. MATERIALS AND METHODS

2.1 Biological Material

The biological material consists of cassava tubers (*Manihot esculenta* Crantz). These are harvested in the city of Bonoua located at 80 km from Abidjan (Ivory Coast).

2.2 Methods of Making Attiéké

To prepare attiéké, cassava tubers of IAC variety were used. The first steps are identical. The tubers are peeled and washed and then a ferment produced from pieces of fresh tubers kept for two to three days in jute bags is added. This is followed by the grinding stage. In the case of the preparation of "attiéké", this stage is preceded by the addition of red oil that has been discolored by heat. The fermentation of the paste follows the grinding stage and takes place for 12 hours. Then, the paste is drained, then wrung out. In the case of the preparation of the attieke, the wrung-out paste undergoes a sieving then a semolina. The semolina is then dried and possibly winnowed when making attieke only. The next step is the steam cooking of the semolina.

2.3 Biochemical Analysis

➤ Determination of pH and acids

The pH was determined by the principle of AOAC [22], according to the potentiometric method,

using the electrode of a pH meter (WTW pH 302). The determination consists of determining the total natural acid content of the product. The hydrocyanic acid content was evaluated by the method of Arreaudau and Sylvestre [23].

➤ **Determination of the moisture content**

It is based on the one proposed by AOAC [22] whose principle is based on the loss of mass of the sample to a constant mass at 105°C.

➤ **Energy value**

The energy value is calculated using the specific coefficients of Atwater [24] for proteins, lipids and carbohydrates.

➤ **Determination of protein**

Crude protein is determined from the determination of total nitrogen, using the Kjeldhal method [22]. Nitrogen in dry matter is determined by the Kjeldahl method after sulfuric mineralization in the presence of selenium catalyst. The nitrogen content is multiplied by 6.25 (nitrogen to protein conversion factor).

➤ **Determination of the lipid content**

The lipid content is determined according to the method described by AFNOR [25], using the Soxhlet as extractor. The extraction of oils is obtained by hexane in a Soxhlet extractor (Unid Tecator, System HT2 1045, Sweden). After evaporation of the solvent and drying of the capsule in an oven at 105 °C for 30 min, the weight difference gives the lipid content of the sample.

➤ **Determination of reducing and total sugars and starch content**

Determination of total sugars were determined according to the method described by Dubois et al. [26] using phenol and concentrated sulfuric acid. Reducing sugars were determined according to the method of Bemfeld (1955) using 3,5 dinitrosalicylic acid (DNS).

Starch content was determined by the formula recommended by FAO (1947) [27].

Starch content = 0.9 (% total carbohydrates - % total sugars).

2.4 Determination of vitamin C

Vitamin C was determined by the method of Pongracz [28]. The amount of vitamin C contained in a 1 mL volume of the supernatant was determined with 2,6-dichlorophenol indophenol until the color changed to a persistent champagne pink.

2.5 Statistical Analysis of Results

The results were subjected to analyses of variance (ANOVA) performed with Statistica 7.1 software to compare the means. In case of significant differences, Duncan's test was used to identify the means responsible for the observed difference at the 5% threshold.

3. RESULTS AND DISCUSSION

Fermentation is a method of food preservation. Lactic acid bacteria produce several natural antimicrobial compounds, namely: organic acids (lactic, acetic, formic, phenyl-lactic, caproic), carbon dioxide, hydrogen peroxide, diacetyl, ethanol and bacteriocins [29]. The production of organic acids during fermentation leads to a significant reduction in pH, which together with the formation of antimicrobial compounds determines the microbial stability of products as well as the motility of pathogenic bacteria and other microorganisms. The action of lactic acid bacteria during fermentation also contributes to the removal of toxic compounds such as cyanogenetic glucosides from cassava [30].

Table 1 shows the pH variation during the preparation of attiéké. The pH of fresh cassava is very low ($6.1 \pm 0.0d$), while during the fermentation of cassava pulp, the pH value after 72h reaches $4.7 \pm 0.2a$. This shows that acidity increases with the duration of fermentation. This increase could be explained by the action of fermenting bacteria. Indeed, during fermentation, bacteria produce enzymes responsible for the hydrolysis of starch into glucose. As a result of the fermentative metabolism, the glucose resulting from the hydrolysis of starch is transformed into lactic acid and various organic acids, hence the decrease in pH during fermentation. In fresh and ground pasta, this study shows that the acid content (acetic and lactic) increases with time. They also increase with the time of fermentation. The semolina pH obtained after 72h of fermentation was similar to the pH obtained (4.4; 4.06) by Krabi et al. [14].

The decrease in pH during fermentation was due to the presence and activity of lactic acid bacteria during spontaneous fermentation. Amoa-Awua and Jakobsen [31] reported that cassava fermentation must be largely a lactic acid fermentation. During the fermentation process, lactic acid bacteria hydrolyze the carbohydrates (especially starch) in cassava into sugars, alcohols and organic acids. The production of organic acids, which increases with the time of fermentation, leads to an increase in the acidity of the samples and the resulting decrease in pH. Several studies have shown that acidity increases with decreasing pH during fermentation [32-34] (Afoakwa and Aidoo 2006).

According to studies by Moorthy et al. [35] and Kobawila et al. [36], several microorganisms (*Saccharomyces cerevisiae*, *Lactobacillus plantarum*, *Lactobacillus brevis*, sp., *Lactobacillus* sp.) involved in fermentation are involved in the transformation of cassava into attieke (fresh semolina). The moisture content of the fresh and milled pasta does not vary, it is identical and in high quantities. Like most agricultural products, water constitutes the major part of the cassava root (60 to 70% of the edible portion, i.e. the peeled root flesh). The remaining dry matter (30-40% of the edible portion) is mostly (90-95%) composed of carbohydrates, proteins (1%), lipids (0.3%), fiber (1%), and mineral elements (0.9%) [37] (Soulé et al., 2013). This rather wet paste is an indicator of a successful fermentation. It favors the proliferation of fermenting microorganisms. Hydrogen cyanide (HCN), a poison contained in cassava that is dangerous to consume [38,39], is eliminated during the technological processes. This corroborates the studies of Oke [40] and Banea et al. [41] who confirm the removal of cyanides during the pressing of the pulp. Indeed, cassava

root generally contains toxic compounds, the cyanogenic glucosides. These are cyanide molecules bound to carbohydrates, particularly glucose molecules [37]. The rate of loss of hydrocyanic acid is very high in the finished product (attieke). The increased reduction of hydrocyanic acid in attieké compared to pastes is thought to be due to the flow of water during the pressing of ground cassava roots, which results in the removal of 90% of hydrocyanic acid. Our results corroborate those of Hongbété et al. [42] who showed that washing results in the removal of almost all hydrocyanic acid from cassava. In addition, culinary treatments such as peeling, cutting, grinding, pressing, and cooking significantly reduce hydrogen cyanide levels. Indeed, according to Onwuka and Ogbogou [7] and Aboua [43], peeling reduces the hydrogen cyanide content by 20-25%.

Starch is the most abundant polysaccharide in cassava [44,45]. This starch is transformed into glucose, maltose and maltodextrin as a result of the action of amylolytic microorganisms responsible for fermentative activity. This study shows that the amount of starch in fresh pulp decreased from $41.14 \pm 0.01\%$ (fresh pulp) to $30.43 \pm 0.01\%$ in raw semolina and 29.50% in fresh attieké (Table 2). That of total sugars from 0.12% to 0.17%, while those of reducing sugars evolve from 0.05% to 0.08%. In attieké, total sugars represent 0.04% and reducing sugars 0.02%. The evolution of starch, total and reducing sugars contents is attributed to the action of lactic acid bacteria that hydrolyze starch into fermentable sugars and degrade them into acids and volatile compounds. Thus, the decrease in starch is correlated with the increase in reducing sugars in fresh attieké. This could be due to the partial hydrolysis of starch during the fermentation phase and during

Table 1. Evolution of some parameters during the preparation of fresh attieké

| Process | Parameters | | | | |
|----------------------------------|------------------|-----------------|------------------|------------------|-------------------|
| | Humidity (%) | pH | Acetic acid | Lactic Acid | Ethanol (ml) |
| Fresh pulp | $61.5 \pm 0.1e$ | $6.1 \pm 0.0d$ | $0.48 \pm 0.01a$ | $0.72 \pm 0.01a$ | - |
| Crushed pulp | $61.5 \pm 0.1e$ | $5.5 \pm 0.2c$ | $0.66 \pm 0.01b$ | $0.99 \pm 0.01b$ | - |
| Fermentation time (Hours) | | | | | |
| 24 Hours | $61 \pm 0.05d$ | $5 \pm 0.1b$ | $1.86 \pm 0.02c$ | $2.79 \pm 0.02c$ | $0.86 \pm 0.01a$ |
| 48 Hours | $60.5 \pm 0.2c$ | $4.8 \pm 0.1ab$ | $3.36 \pm 0.02f$ | $5 \pm 0.01f$ | $3.36 \pm 0.005d$ |
| 72 Hours | $60.5 \pm 0.2c$ | $4.7 \pm 0.2a$ | $4.68 \pm 0.01g$ | $7 \pm 0.01g$ | $4.68 \pm 0.01e$ |
| Semolina raw | $51.2 \pm 0.32b$ | $5 \pm 0.01b$ | $2.48 \pm 0.01e$ | $4.5 \pm 0.03e$ | $2.48 \pm 0.01c$ |
| Cooked semolina (Attieke fresh) | $45 \pm 0.005a$ | $5 \pm 0.01b$ | $2.4 \pm 0.01d$ | $3.6 \pm 0.02d$ | $2.4 \pm 0.02b$ |

Table 2. Evolution of some parameters during the preparation of fresh attiéké

| Process | Parameters | | | |
|--------------------------------------|---------------|----------------|-----------------|----------------|
| | Starch % | Total sugars | Reducing sugar | Vitamin C (mg) |
| Fresh pulp | 41,14 ± 0,01f | 0,2 ± 0,01e | 0,06 ± 0,003d | 69 ± 1f |
| Crushed pulp | 41,13 ± 0,01f | 0,117 ± 0,002a | 0,057 ± 0,002cd | 65 ± 2,5e |
| Durée de fermentation (Heure) | | | | |
| 24 H | 39,13 ± 0,02e | 0,121 ± 0,003a | 0,053 ± 0,002bc | 63 ± 2e |
| 48 H | 34,87 ± 0,02d | 0,125 ± 0,001a | 0,05 ± 0,002ab | 57 ± 1d |
| 72 H | 33,86 ± 0,03c | 0,142 ± 0,003b | 0,047 ± 0,002a | 49 ± 2c |
| Semolina raw | 30,43 ± 0,01b | 0,17 ± 0,003d | 0,08 ± 0,002e | 35 ± 1b |
| Cooked semolina (Attieke fresh) | 29,5 ± 0,02a | 0,15 ± 0,002c | 0,05 ± 0,003ab | 1 ± 0a |

cooking [6]. These results confirm those of Padomou et al. [46] who observed the sweet taste of “placali”, a foodstuff obtained with the same processes as attiéke. The manufacturing process of attiéké contributes to modify the physicochemical and biochemical compositions of the final product. Thus, the contents of lactic and acetic acids, total and reducing sugars and starch in the attiéke differ from those obtained during the fermentation process.

The vitamin C content of fresh cassava pulp (69 ± 1f mg/100g) decreases during the preparation of attiéké after the third day of fermentation. Thus, the fresh attiéké obtained at the end of the process is low in vitamin C. This observation is strongly justified because vitamin C is heat labile. This food is essentially energetic with a high level of lactic and acetic acids, which gives it its acidic taste. Although it is a fermented product, the production technology totally eliminates the alcohol and most of the vitamin C.

4. CONCLUSION

The objective of this study is to establish a database with organoleptic properties and nutritional value useful for national specifications and nutritional advice. Attieke is a foodstuff widely consumed by the Ivorian population and is now known internationally. The production process of attiéke shows a variability of parameters such as starch, total and reducing sugars and different organic acids measured during fermentation. All these parameters are influenced by the action of fermentative bacteria introduced in the fresh pulp. The cooking of fermented raw semolina shows a

considerable decrease of vitamin C at the trace stage.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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