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Effect of Harvest Date on Technological Yield and Evolution of Hydrocyanic Acid Loss Rate after Transformation of Cassava Root (*Manihot Esculenta* CRANTZ) from Yacé Variety by Placali and Attiéké Consumed in Côte d'Ivoire

Allou Christian Armel Gnamien[1], Adingra Kouassi Martial-Didier[2], Dje Kouakou Martin[3], Tchumou Messou[4], Tra-Bi Fézan Honora[5], Tano Kablan[6]*

[1] Doctoral Program in Food Sciences and Technology, [2-6] Research Officers

[1-4,6] Department of Food Sciences and Technology

[5] Department Sciences of Nature

University of Nangui Abrogoua

Abidjan,

Côte d'Ivoire

ABSTRACT

In order to contribute to their better utilization and valorization, tuberous roots of cassava (Manihot esculenta CRANTZ) of the yace variety consumed in Côte d'Ivoire have drawn our attention. Four different harvest periods of these tuberous roots were used in the study. Cassava tubers were harvested at 11th, 12th, 13th and 14th months after planting. The hydrocyanic acid loss rate and technological yield after the transformation of cassava roots (harvested at the 11th, 12th, 13th and 14th months after planting) into placali and attiéké were investigated. The results showed that the products obtained with the 11th month of harvest had the greatest losses. Peeling (29.59 % for attiéké and 36.68 % for placali) and pressing (33.32 % for attiéké and 34.56 % for placali) are the stages causing the most significant losses during the transformation of cassava roots into placali and attiéké. The technological yield increases with the harvest period and falls after the twelfth month. The maximum corresponding to the 12th month of harvest is 81.65 % for attiéké and 70.83 % for placali. Regarding the rate of loss of hydrocyanic acid, it was more important at the eleventh month of harvest for placali and attiéké with respective values of 95.85 % and 94.11 %. Cassava tubers harvested at the 12th month after planting are therefore ideal for the production of attiéké and placali.

Key Words: *Cassava roots, Harvest periods, Placali, Attiéké, Technological yield.*

1. INTRODUCTION

Cassava (*Manihot esculenta* CRANTZ) is mainly grown for its roots and leaves and contributes to food security [1]. It is consumed by more than one billion people worldwide mainly its roots and leaves [2]. The high consumption of its organs, as well as the numerous products that result from it, make this commodity a culture of subsistence and rent, especially for producers and other operators in the sector [3]. Cassava roots produce more carbohydrates per hectare than cereal crops and can be grown at considerably lower cost [4]. It contains 70 % starch and is the fourth largest source in developed countries and even in the world [5]. It is grown as both food and industrial raw material [6]. It is the third-rich agricultural resource after rice and maize in tropical countries [7]. Cassava roots products contain a significant proportion of carbohydrates and minerals [8]. The leaves, on the other hand, are rich in protein, vitamins (A and C) and mineral salts [9].

C. author: pasqual_kab@hotmail.com

Cassava is the second food production in Côte d'Ivoire after yam and in front of plantain [10]. It is also, according to FAO [11], the 4th largest vegetable production in the world after maize (1068.9 million tons), wheat (727.9 million tons) and rice (513 million tons). Global cassava production was estimated at 277.07 million tons in 2018, while Africa produced 160.73 million tons in the same year. In Africa, Nigeria remains the leading producing country with 56 million tons, while Côte d'Ivoire produced much less with an average of 5.37 million tons in 2018 [11]. It is mainly grown in the south of the country [12] and traditionally processed into fermented products (attiéké, placali, gari etc.) and then into rapid meal preparation [13]. Unfortunately, freshly harvested cassava roots deteriorate rapidly and the process begins 1 to 3 days after harvest [14].

Due to high demand, some producers are harvesting cassava tubers early and this could influence the technological yield and the evolution of the hydrogen cyanide loss rate of this organ after it has been transformed into placali and attiéké.

Only a few publications have reported the effect of harvest date on the technological yield and changes in the rate of hydrogen cyanide loss from cassava roots [15]. However, the composition of fruit and vegetables, especially the roots, depends on the level of maturity.

The aim of this study is to contribute to a better use of the yacé variety cultivated in Côte d'Ivoire. It will be necessary to determine the influence of the harvest date on the technological yield and the evolution of the rate of loss of hydrogen cyanide from cassava after its transformation into placali and attiéké.

2. MATERIAL AND METHODS

2.1 Plant material

The plant material consists of the fresh tuberous roots of the cassava (*Manihot esculenta* CRANTZ) yacé variety.

2.2 Methods

2.2.1 Experimental device

The cultivation was carried out on an experimental plot at N'dotré (latitude: 5.463611, longitude: -4.115969 and altitude: 99.00), a sub-district of the Abobo Commune, north of Abidjan. The field was made with 20 cm cuttings with 5 to 7 nodes, from healthy 12-month-old stems. They were planted at a spacing of 0.8m x 0.8m, a density of 15625 plants / hectare. The experimental plot was divided into 4 blocks (A, B, C and D) of 125 m^2 each and 3 m apart, delimited by a 3 m firewall. Each block consisted of ten (10) ridges of ten (10) plants. The lines were 0.8 m apart inside the blocks, giving a total area of 1870 m^2, or 0.1870 ha. Two months after planting the cuttings, the soil was enriched with NPK (15-15-15) at the rate of 20 g/cassava plant. The tuberous roots of cassava were harvested at four stages after the planting of the cuttings: 11th, 12th, 13th and 14th months.

2.2.2 Sampling

Thirty (30) cassava plants were randomly selected from each of the 4 blocks depending on the stage of harvest (11th, 12th, 13th and 14th months after planting). The four harvests were carried out on the 8th of March, the 10th of April, the 8th of May and the 7th of June of the year 2017. When the harvest took place between 7 a.m. and 10 a.m., the stems were cut 30cm from the ground, with a machete and the roots pulled away, taking care not to cut them. At each stage of maturity, the roots were separated into two batches labeled with the following statements: the date of harvest and the type of use. The first batch (100 Kg) served for the production of attiéké. The second batch (100 Kg) was used to produce placali. These two batches were sent to Niangon-Lokoua to produce placali and attiéké, which were physically analyzed before being transported to Nangui Abrogoua University for the determination of hydrocyanic acid. Physical and chemical measurements were repeated three times.

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Transformation of tuberous cassava roots

From tuberous roots, many products can be obtained such as placali and attiéké (Figure 1).

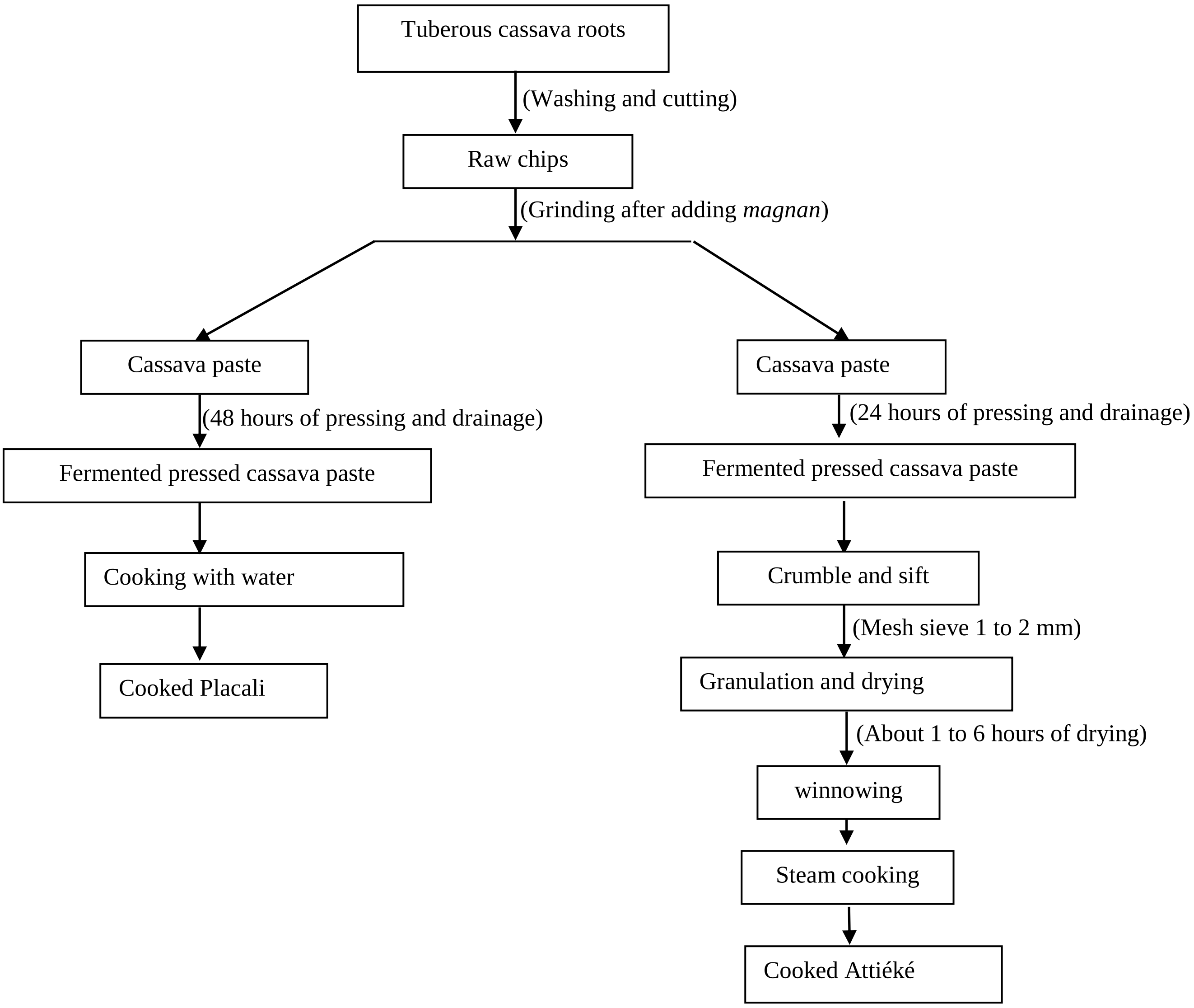

Figure 1: Traditional processes of processing fresh cassava roots into attiéké and placali.

2.2.3 Technological yield of cassava roots

Cassava roots were weighed before and after they were transformed into placali or attiéké for the evaluation of technological yield.

$$T_P\,(\%) = \frac{(P_m)}{R_m} \times 100 \text{. ------------------ (1)}$$

Tp: Technology yield
R_m: Root mass before transformation
P_m: Product mass obtained

2.2.4 Determination of the losses to each unit operation of transformation of the roots of cassava

Cassava roots were weighed at every unit operation, from their transformation into placali or attiéké, for the assessment of losses caused by certain operation. Thus, the steps chosen for the attiéké are: peeling, pressing, emoting and formation of semolina then drying in the sun and vanning. However those targeted for the placali are: peeling, pressing, dough crushed in a mortar and then pressed, the must diluted and filtered the last step was cooking.

DOI: 10.31695/IJASRE.2020.33671

$$SP(\%) = \frac{(M_{S\ (n)})}{MS_{\ (n-1)}} X\ 100. \text{ --------------- } (2) \qquad PS(\%) = RS_{\ (n)} - RS_{\ (n-1)}. \text{ --------------------------- } (3)$$

SP: Stage Performance
$Ms_{(n)}$: Mass of sample at stage (n)
$Ms_{\ (n-1)}$: Sample mass before step (n)
PS: %age of stage losses
$Rs_{\ (n)}$: Stage performance (n)
$Rs_{\ (n-1)}$: Performance before stage (n)

2.2.5 Hydrocyanic acid assay for loss rate determination

Hydrocyanic acid determination was done using the [16] method. Twenty (20) g of fresh paste or attiéké or placali from the transformation of cassava roots were macerated in 200 cm^3 of distilled water for 3 to 4 hours, followed by distillation to collect distillate on 20 cm^3 of soda solution containing 0.5 g of soda. Then, 100 cm^3 of the distillate are taken and 8 cm^3 of potassium iodide (KI) at 5 % is added. The dosage is done with a silver nitrate solution ($AgNO_3$, 0.02 N). According to this method, the CN- ion tends to combine with the Ag ion, to form an AgCN silver cyanide precipitate. This precipitate does not form in an ammonia medium. The end of the reaction is achieved when all CN- ions have reacted; Ion Ag is combined with the I- ions of the potassium iodide indicator (KI) and silver nitrate ($AgNO_3$) makes the solution opalescent. In the amount of $AgNO_3$ in mL obtained at the end of the dosage, the amount of hydrocyanic acid (HCN) in sample mg is obtained by the formula:

$$A \times 1.08 = \text{mg HCN.} \text{---------------------------- } (4)$$

The hydrocyanic acid content obtained with attiéké and placali was used to determine the rate of loss of water cyanide according to the following formulas:

$$T(\%) = \frac{(S_{HCN})}{(C_{HCN})}\ x\ 100. \text{ ------------------ } (5) \qquad R(\%) = 100\ \% - T. \text{ ------------------------- } (6)$$

T: Sample hydrocyanic acid levels
C_{HCN}: Fresh cassava hydrocyanic acid content
S_{HCN}: Sample hydrocyanic acid content
R: Rate of hydrocyanic acid loss

2.2.6 Statistical analysis

Statistical analysis assessed the influence of harvest date on each of the parameters studied by factor variance analysis (ANOVA). When a significant difference was observed, Duncan's test was used to show it at 95 % confidence level. Statistica 7.1 software was used for this statistical analysis.

3. RESULTS

3.1 Yield after processing fresh cassava roots into attiéké and placali

The yield after transformation of cassava roots into attiéké increased from 76.56 % to 81.65 % from the eleventh to the twelfth. However, it declined after the twelfth month to 76.92 % in the fourteenth month of harvest (Figure 2). Statistical analysis shows that there is no significant difference between yield values after processing cassava roots, at eleventh and fourteenth month of harvest attiéké. However, it reveals a significant difference ($P < 0.05$) between the yield values of the eleventh and fourteenth months and those of the twelfth and thirteenth month of harvest.

The twelfth month of harvest has the highest placali yield (70.83 %). This yield ranges from 68.76 % to 70.83 % from the eleventh to the twelfth month. However, it decreased after the twelfth month to 64.68 % at the fourteenth month of harvest (Figure 2). Statistical analysis shows that there is no significant difference between yield values after processing cassava roots, at eleventh and thirteenth month of harvest placali. However, it reveals a significant difference ($P < 0.05$) between the yield values of the eleventh and thirteenth months and those of the twelfth and fourteenth months of harvest.

DOI: 10.31695/IJASRE.2020.33671

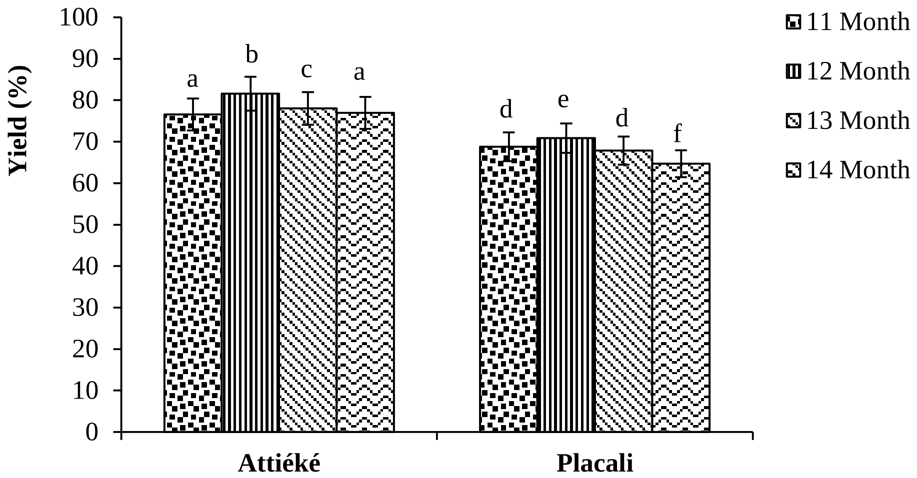

Figure 2: Yield (%) after transformation of cassava roots into attiéké or placali based to the harvest month

Histograms of means ± standard deviation topped with the same letter are not statistically different at the 5% threshold according to the Duncan test.

3.2 The rate of mass loss after cassava roots transformation

The different losses observed after the transformation of cassava roots into placali and attiéké are greater when peeling and pressing the roots. Thus, the peeling of the roots caused greater losses in the fourteenth month of harvest after planting. They were 29.59 % and 36.68 %, respectively, in the production of attiéké and placali. But for the largest losses due to pressing, they were observed at the eleventh month of harvest. They were 33.32 % and 34.56 % for attiéké and placali respectively (Figures 3 and 4). Statistical analysis reveals that there is a significant difference ($P < 0.05$) between the loss values of all unit operations of placali and attiéké production.

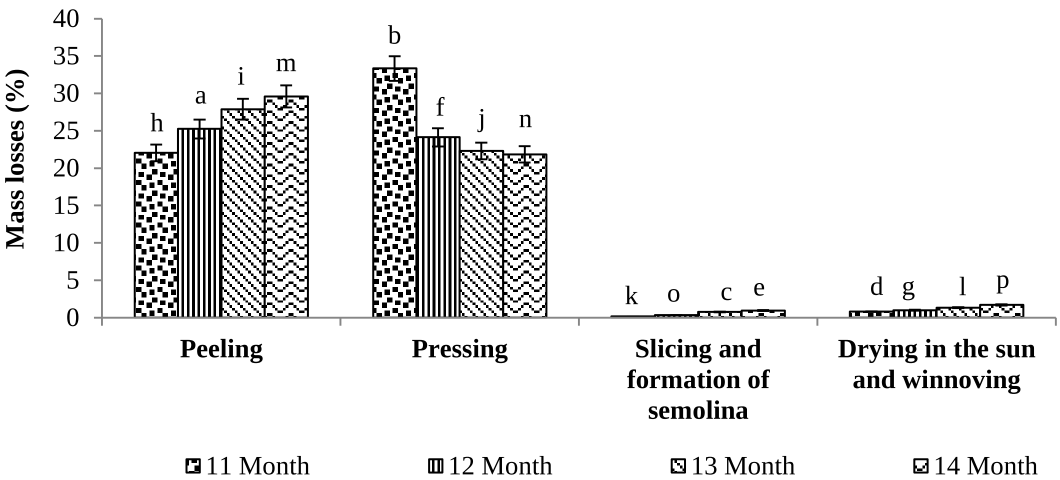

Figure 3: Mass losses (%) during attiéké production

Histograms of means ± standard deviation topped with the same letter are not statistically different at the 5 % threshold according to the Duncan test.

DOI: 10.31695/IJASRE.2020.33671

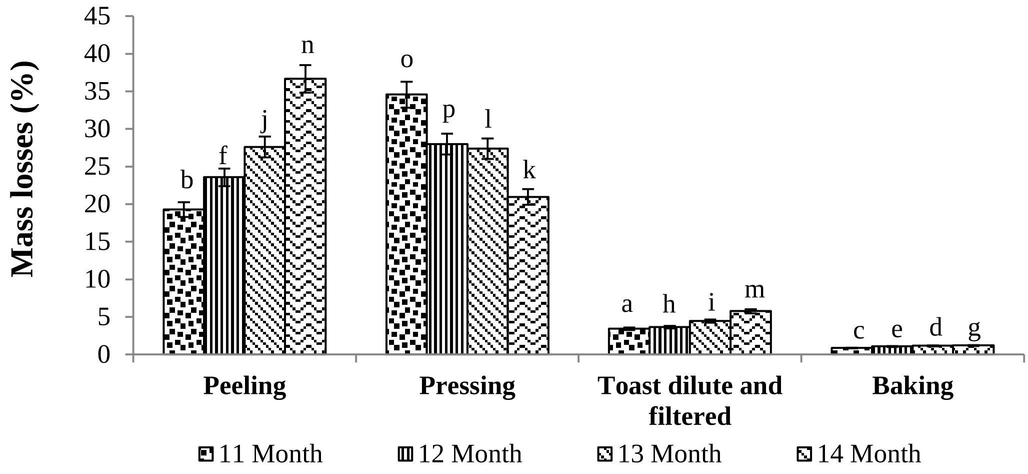

Figure 4: Mass losses (%) during placali production

Histograms of means ± standard deviation topped with the same letter are not statistically different at the 5 % threshold according to the Duncan test.

3.3 Hydrocyanic acid content

The levels of hydrocyanic acid in the fresh cassava roots, placali and attiéké increase from the eleventh to the fourteenth month of harvest (Figure 5). They range from 8.59 ± 0.01 to 10.58 ± 0.02 mg/100 g of FW, 0.35 ± 0.01 to 0.70 ± 0.01 mg/100 g of FW and 0.50 ± 0.01 to 0.89 ± 0.01 mg /100 g FW for fresh cassava roots, placali and attiéké respectively. The fourteenth month of harvest has the highest levels of hydrocyanic acid in any sample. According to the statistical analysis, there is no significant difference between the levels of hydrocyanic acid in placali and attiéké obtained in the eleventh and twelfth months of harvest, respectively. This same remark is revealed by the statistical analysis of the placali and attiéké obtained in the thirteenth and fourteenth month of harvest. Nevertheless, statistical analysis reveals a significant difference ($P < 0.05$), between the levels of hydrocyanic acid in the samples already cited and those of the other samples.

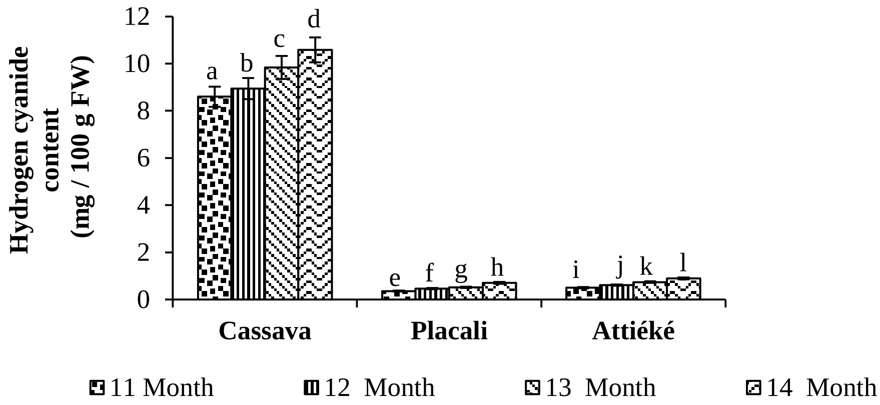

Figure 5: Quantity of hydrocyanic acid depending on the month of harvest

Histograms of means ± standard deviation topped with the same letter are not statistically different at the 5 % threshold according to the Duncan test.

3.4 Rate of hydrocyanic loss after cassava roots transformation

Loss rates of hydrocyanic acid after transformation of cassava roots into placali and attiéké decline from the eleventh to the fourteenth month of harvest (Figure 6). They vary from 95.85 % to 93.32 % and from 94.10 % to 91.56 % for placali and attiéké, respectively. The rate of loss of hydrocyanic acid is greater at the eleventh month of harvest for placali and attiéké. The statistical analysis of the hydrocyanic acid loss rate values revealed a significant difference ($P < 0.05$) between all the values of the loss rates of hydrocyanic acid of attiéké obtained from the eleventh to the fourteenth month of harvest. The statistical analysis reveals also that there is no significant difference between the hydrocyanic acid loss rates of the placali obtained at the twelfth and

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thirteenth month of harvest. However, it reveals the existence of a significant difference ($P < 0.05$), between these rates already mentioned and those of the other harvest months regardless of the sample.

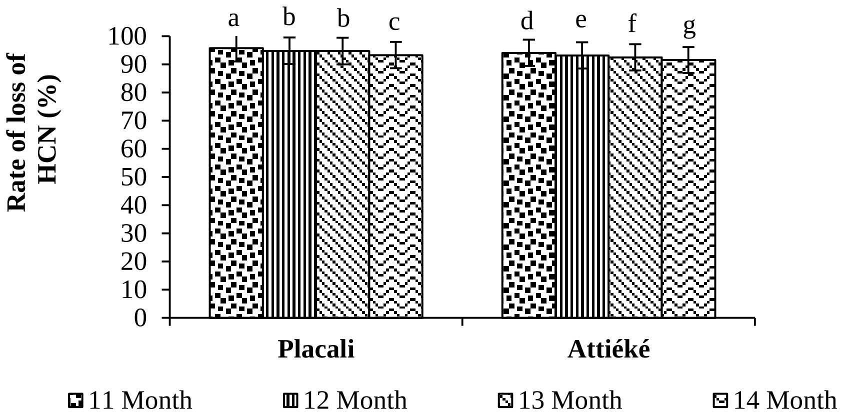

Figure 6: Rate of cyanhidic acid loss based on harvest month

Histograms of means ± standard deviation topped with the same letter are not statistically different at the 5 % threshold according to the Duncan test.

4. DISCUSSION

The influence of the maturity stage of cassava tubers has shown a raise in technological yield before the twelfth month and decline after this month of harvest. In fact, from eleventh to the twelfth month, there is a decrease in moisture levels as tubers become more and more mature. In addition, in this stage of harvest cassava bark is not too thick and tubers do not contain a large amount of fiber and this favors an increase in the technological yield after the transformation into attiéké or placali. Several reports have already shown that the level of tuber maturity significantly influences the technological yield [17, 18, 19]. After the twelfth month of harvest, the fiber become more and more abundant in the tubers and this causes great loss during the different unit processing operations. This decline in technological yield after the twelfth month is due to the increase in the rate of losses observed during the transformation of tuberous cassava roots into attiéké and placali following the treatments undergone by them. The peeling of the roots of cassava and the pressing of the dough, lead to a significant decrease of the mass. Indeed, according to [20] cassava roots is composed of 4-5 % outer bark, 15-20 % inner bark. Thus, after peeling the loss rate is between 19 and 25 %. Also the losses in peeling are all the higher as the tuberous roots are small and irregular [21, 22]. In addition, the decrease in moisture when pressing the dough could also explain this loss of mass. Reference [23] confirm that the decrease in moisture could be explaining the mass loss during traditional cassava technology.

Cassava roots harvested at 12 months after planting showed better technological yield compared to cassava harvested at 11^{th}, 13^{th} and 14^{th} months after planting cassava. It would be beneficial to produce attiéké and placali with cassava harvested every 12 months after planting. Farmers will therefore have to harvest from the twelfth month after planting. As for processors, they will have to use the roots from the twelfth month of harvest to increase their technological yield.

Regarding the significant mass loss caused by the decrease of the humidity rate in attiéké compared to placali, it would be due to the treatments suffered by the paste of attiéké in addition to the pressing. Indeed, after pressing the dough that will be used to produce the attiéké is granulated and dried before the grains are cooked. Reference [24] have already mentioned this finding during their work on three traditional Ivorian dishes made from cassava. This same observation was made during the work done by [25] on attiéké. Their work reveals that the semolina used to prepare attiéké is granulated and then partially dried to reduce its moisture content. In contrast, to placali which is prepared with filtrate of fermented cassava paste [26].

Loss of mass after transformation of the tuberous roots into placali and attiéké could also be attributed to the elimination of the fibers contained in the roots from which these dishes derive from the treatments they undergo before cooking. Several studies have already shown that the different unitary production operations of attiéké and placali considerably reduce the fiber content [27, 28, 29, 30], thus eliminating part of these fibers during the production of attiéké and placali, respectively, during the winnowing and sieving will necessarily lead to a loss of mass in products derived from these tuberous roots of cassava.

The rate of loss of hydrocyanic acid is very high for both products (attiéké and placali) in any month of the cassava tuber harvest. The increased reduction of hydrocyanic acid in attiéké and placali relative to fresh cassava roots is thought to be due to the flow of water during the pressing of crushed cassava roots which allows the removal of 90 % hydrocyanic acid. Our results corroborate those of [31] showed that washing results in the elimination of almost all the hydrocyanic acid content of cassava. In addition, culinary treatments such as peeling, cutting, grinding, pressing and baking significantly reduce the level of hydrogen cyanide. Indeed, according to [32] and [33] peeling reduces the hydrocyanic acid content by 20 to 25 %.

DOI: 10.31695/IJASRE.2020.33671

Similarly, [34] has shown that grinding contributes to this elimination by destroying cell tissues containing cyanogenic glycosides, which will facilitate the reduction of the hydrocyanic acid content after pressing of the paste. Also, the decrease in the level of hydrocyanic acid in attiéké and placali could be attributed to fermentation according to [32]. The work done by [33] on cassava roots attributes this drop in the level of hydrocyanic acid to pressing, drying and cooking. Cooking itself causes a sharp drop in the level of hydrocyanic acid. In fact, hydrocyanic acid is very volatile from 27 °C [35].

As [35] has shown, post-treatment cooking considerably reduces its content in attiéké and placali. However, the residual content of hydrocyanic acid observed respectively in attiéké and placali, which varies from 0.35 to 0.71 mg/100 g FW and from 0.5 to 0.89 mg/100 g FW, would be safe for the organism, the threshold of toxicity being between 5 and 6 mg/100 g FW [17] and the value recommended by the FAO being 1 mg/100 g FW.

5. CONCLUSION

This study evaluated the impact of the harvest date on the technological yield and the rate of hydrocyanic acid loss during the transformation of cassava tuberous roots into attiéké or placali. Technological yield after transformation of cassava roots into attiéké and placali decreased after the twelfth month of harvest. Peeling and root pressing are the steps that cause the greatest declines in technological performance. With regard to the level of hydrocyanic acid in tuberous roots of cassava, it is declining after root transformation into placali and attiéké. In addition, the rate of loss of hydrocyanic acid is greater at the eleventh month of harvest for placali and attiéké. The results showed that the twelfth month of harvest is the most recommended for the production of attiéké and placali.

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