



Influence of the Cassava Harvest Month on the Sensory Parameters of Attiéké

Allou Christian Armel Gnamien¹, Amoikon Tiemele Laurent Simon¹, Adingra Kouassi Martial-Didier¹, Brou Koffi Siméon¹, Tano Kablan¹

¹Department of Food Sciences and Technology, University of Nangui Abrogoua, Abidjan, Côte d'Ivoire

*Corresponding Author: Allou Christian Armel Gnamien

Email: allouchristianarmel@yahoo.fr



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Abstract

Cassava is an important staple food around the world, especially in Africa. It is cultivated throughout the Ivorian territory with predominance in the South. Due to the high demand, some producers opt for an early harvest, neglecting the impact of the harvest stage on the sensory parameters of cassava root derivatives. The objective of this work was to determine the stage of harvest allowing obtaining products of good sensory quality. The sensory characteristics of the attiéké were evaluated at different stages of harvest (11th, 12th, 13th and 14th months after planting the cuttings) of the cassava roots of the Yacé variety which were used for its production. The attiéké obtained in the twelfth month of harvest was generally much appreciated because it was less acidic, less fibrous and more homogeneous and had a better smell. Thus, cassava harvested in the twelfth month of cultivation makes it possible to obtain attiéké with the best sensory characteristics. Therefore, this stage of maturity of cassava roots is recommended for attiéké producers.

Introduction

In order to contribute to their better use and recovery, the roots of cassava (*Manihot esculenta* CRANTZ), of the Yacé variety consumed in the Ivory Coast, have drawn our attention. Cassava is a dicotyledonous, perennial plant cultivated worldwide and belonging to the Euphorbiaceae family (Perera et al., 2013). It was introduced to Côte d'Ivoire in the 19th century by Akan immigrants (Abouré and Alladjan) from southern Ghana (Brou et al., 2012). It is cultivated throughout the Ivorian territory with predominance in the South (Kouadio et al., 2010).

According to the FAO (2018), it is the 4th largest crop production in the world after maize (1068.9 million tonnes), wheat (727.9 million tonnes) and rice (513 million tonnes). Its world production was estimated in 2018 at 277.07 million tonnes, of which 160.73 million tonnes were produced by Africa. In Africa, Nigeria remains the leading producer country with 56 million tonnes while Côte d'Ivoire produced much less with an average of 5.37 million tonnes in 2018 (FAO, 2018).

There are sweet and bitter varieties in Côte d'Ivoire (Purseglove, 1969). However, the Yacé or IAC (Improved African Cassava) variety, a bitter variety introduced in Côte d'Ivoire in the 1970s and 1980s, is the most cultivated in large production basins (Mendez del Villar et al., 2017). The main criterion of its choice is obviously its productivity in dry matter or starch (Assanvo et al., 2019). Cassava roots are processed into several products including *attiéké* (Yao et al., 2015), *placali* (Koko et al., 2012), *attoukpou* (Nevry et al., 2007), starch (Ehui, 2009) and *gari* (Sotomey, 2001) etc.

The functional analysis of the cassava sector revealed that the growing demand for *attiéké* for urban centers and export sectors is now creating interesting income opportunities, especially

for women who are at the center of production, processing and marketing operations (Mendez del Villar et al., 2017).

Attiéké is a whitish colored food with a slightly tart taste made from fermented steamed cassava meal (Assanvo, 2008). The annual consumption of *attiéké*, which was estimated in 2001 to be between twenty-eight (28) and thirty (30) kg per capita (FAO, 2001), increased in 2014 to one hundred (100) kg per capita according to the Ministry of Agriculture (Trazié, 2019). This significant demand is pushing some producers to opt for an early harvest. However, in 2005, N'zué et al. (2005), placed the harvest stage of cassava roots of the Yacé variety between the twelfth and the twentieth month, while the work carried out by Ebah (2014), fixed it at the thirteenth month of harvest to obtain good physicochemical characteristics of cassava roots and *attiéké*. Some recent studies have shown that the physico-chemical composition of cassava roots can be influenced by the stage of harvest (Kazeem and Abdulganiy, 2013; Ebah, 2014). However, these studies did not address the variability in sensory parameters of the obtained *attiéké* depending on the stage of harvest of the processed cassava roots. However, when the harvest is carried out late in acidity, the fiber and hydrocyanic acid content increase, while that of carbohydrates decreases as does the sweet taste (Giraud et al., 1998; Michael et al., 2015; Nartey, 1993; Keating et al., 1982). Thus, the delay in the harvest allows the producer to have a high yield and therefore optimized earnings. However, the processor who buys this type of roots will not necessarily have products of good sensory qualities. Therefore, it would be important to be able to accurately control the harvest stage to obtain products of good sensory quality. Thus, to better appreciate the variation of its parameters, the harvests will be carried out block by block from the eleventh to the fourteenth month of maturity. That is, one month before the interval indicated by N'zué et al. (2005) and one month after the harvest month indicated by Ebah (2014).

The objective of this study is to evaluate and compare, depending on the stage of harvest, certain sensory parameters of the *attiéké* resulting from the transformation of the roots of cassava grown in Côte d'Ivoire, particularly the Yacé variety. Specifically, it will be a question of determining the impact of the harvest stage on the color, the presence of fibers, the homogeneity, the consistency, the sourness, the sweetness, the friability and the odor of the *attiéké*

Plant Material

The roots of the Yacé variety of cassava (*Manihot esculenta* Crantz) constituted the plant material

Methods

Experimental Apparatus

Cassava cultivation was carried out from April 2016 to June 2017, i.e. 15 months on an experimental plot in total randomization with four replicates, in Akoupé zeudji, a commune of Abidjan (Côte d'Ivoire). The latitude of 5.463611, the longitude of -4.1155969 and the altitude of 99.00, were the coordinates of the parcel. It was perfectly drained because of its low slope. The soil was of the ferralitic type with a sandy clay texture that benefited from a tropical climate. The average temperature was 25.8 ° C, with an average precipitation of 1744 mm. The culture was carried out with cuttings of 20 cm presenting 5 to 7 nodes, resulting from stems 12 months old. They were planted on April 07, 2016 and the replacement of the missing feet was carried out fifteen (15) days after the cuttings were planted. Planting was carried out with a spacing of 0.8 m between the plants in length and width, ie a density of 15,625 plants / hectare. The experimental plot was delimited by a 3 m firewall and divided into 4 blocks (A, B, C and

D) of 125 m² each and 3 m apart. Each block consisted of ten (10) logs of ten (10) plants. The lines were 0.8 m apart inside the blocks, giving a total area of 1870 m², or 0.1870 ha. The experimental plot was maintained weekly. Cassava roots were harvested block by block at four stages after planting (eleventh, twelfth, thirteenth and fourteenth month of harvest after planting the cuttings).

Harvest and Sampling

Once the tested maturity stage has been reached, i.e. 11th, 12th, 13th and 14th month after planting the cuttings, thirty (30) cassava plants were randomly chosen from one of the 4 blocks at rate of 3 plants per row of ten plants. The harvests were carried out respectively on March 08 (block A), April 10 (block B), May 08 (block C) and June 07 (block D), of the year 2017 between 7 a.m. and 10 a.m. To do this, the stems were cut 30 cm from the ground, using a machete, and the roots pulled out, being careful not to nick them. Once the roots (100 kg) were harvested, they were transported to Niangon-lokoua, a village in the commune of Yopougon located in the city of Abidjan, where the producer chosen for the transformation of cassava roots into *attiéké* was located. Once obtained, these dishes were transported to Nangui Abrogoua University in Abidjan Côte d'Ivoire for sensory analysis.

Transformation of Cassava Roots into *Attiéké*

One hundred (100) kilograms of fresh cassava roots were peeled using stainless steel knives. The peeled roots were then cut into chips and the fibers removed to facilitate grinding. The fresh chips obtained were washed two (02) times with water (50 liters), by rubbing by hand in order to get rid of the various impurities (grains of sand, pieces of bark, etc.). The fresh cassava chips were then ground in the presence of 3.25 liters of water and 205.25 ml of unrefined palm oil (red oil) using an electric hammer grinder into a fine paste after addition of 7 kg of mangnan which is a ferment obtained after peeling, boiling and fermentation of the tubers for two (02) days (Djéni et al., 2014). The ground material obtained previously was introduced into jute bags. These bags containing the fermented ground material were introduced under vacuum presses to allow fermentation using the strains of lactic acid bacteria present in the mangnan for one (01) day and the elimination of the water containing cyanogenic glucosides. After the day of fermentation, the dehydrated compact dough was crumbled and sifted using a sieve of 1 to 2 mm mesh size, by a continuous circular motion of the hand to make it crumbly while removing fibers and uncrushed pieces of cassava. Then, the semolina was made by hand in a large bowl held obliquely with one hand and one knee while the second hand threw the sifted particles, which had become more or less friable, against the wall of the bowl. The semolina thus obtained was left in the open air on vans and plastic films, to allow them to dry in the sun for 4 hours. The dried semolina underwent winnowing before cooking to remove fibers of smaller sizes. Finally, the cooking was carried out with steam using a couscous-maker placed on a pot that contained water. The pot was heated by the fire of a butane gas and the semolina in the couscous-maker turned with a spatula, as the water boiled until they were cooked (Figure 1).

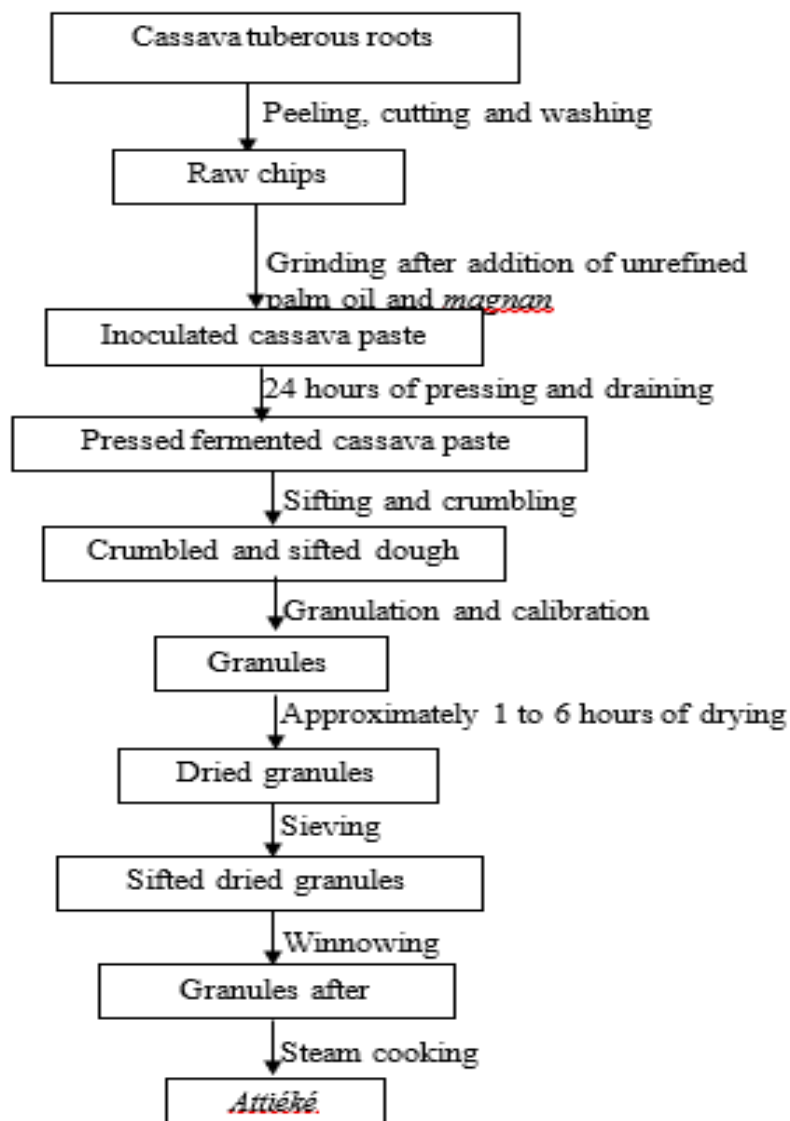


Figure 1. Traditional processes for transforming fresh cassava roots into attiéké

Sensory Analysis of Attiéké

For this sensory analysis of the *attiéké* two types of tests were chosen:

Descriptive Test

This test was used, to assess the sensory magnitude involving the research-based methodology and the quantification of the descriptor. It allows the product to be analyzed to be described with a minimum of words so as to give it an identity card, reproducible and recognized by all (Diamondra, 2017).

Training of Panelists

Three training sessions per week were organized over a period of 4 weeks. During the first four training sessions, the *attiéké* was described by the panelists with their own descriptors and rating scale. However, two other sessions made it possible to retain a final list of descriptors (Table I) and 5-point scales. During the last six training sessions, the panelists were familiarized with the list of descriptors and the corresponding scales. Their capacity for

reproducibility in their scoring was checked at the end of the training. Thus, the panelists were able to describe the *attiéké* well.

Evaluation of Descriptors

Sensory evaluation was performed according to the procedure described by Watts et al. (1991) with some modifications. It took place in a closed classroom with white (neon) light, at Nangui Abrogoua University in Abidjan Côte d'Ivoire, away from auditory and visual distractions. This room has been fitted out to adapt it to a sensory analysis room, i.e. clean with a temperature of 25 ± 1 ° C and equipped for the occasion with a spittoon, spoons, towels and water. Water to rinse your mouth. An evaluation session was organized once a month for four months. During the sessions, which took place between 11 a.m. and 1 p.m., the trained panelists were given a dish of *attiéké*. This dish was represented by a three-digit code taken from a table of random numbers (Dadzie & Orchard, 1997). A comprehensive questionnaire using clear, unequivocal terms and not too long was developed. It also presented the samples in order and was designed to produce accurate and valid data. The sensory descriptors retained according to the senses were as follows:

- visually, the color, the presence of fibers and the homogeneity;
- taste, consistency, sourness and sweetness;
- at the tactile level, the friability;
- at the olfactory level, the smell.

Each panelist received a dish in a disposable plastic plate. For each sensory descriptor, the subjects used a scoring sheet which provided information on the correspondence between the scoring and the descriptor (defined in Table I). The scores were assigned to the different sensory descriptors retained for each dish, by the evaluators who had a 5-point scale ranging from 1 to 5, with 1 = no, 2 = little, 3 = average, 4 = very and 5 = extremely, depending on the intensity of the stimulus perceived (Lateur et al., 2001).

Hedonic Test

This test was used to determine the preference of naïve consumers for *attiéké*. Each panelist gave their opinion on the very bad or very good character, using a rating scale from 1 to 5 by filling out an individual sheet.

Panelists Choice

The panel was made up of 60 people made up of thirty (30) girls and thirty (30) boys whose ages varied between 25 and 30 years old, all students of the Food Science and Technology Training and Research Unit of the Nangui Abrogoua University of Abidjan Ivory Coast. These panelists were naïve about the overall assessment of the *attiéké* studied.

Hedonic Evaluation

The sensory analysis was carried out in the same room set up for the descriptive analysis on the same day, at the rate of one session per month for four months. The dishes were presented to the 3 groups of 20 panelists from 1 p.m. to 4 p.m. These dishes were represented by a three-digit code, taken from a table of random numbers (Dadzie & Orchard, 1997) and in a different order for each individual to avoid order effects. The panelists were instructed to taste the *attiéké* sample and to indicate their overall assessment on a 5-point hedonic scale ranging from "very bad" to "very good", by completing an individual sheet.

Table 1. definition of some descriptors used in this study for sensory analysis

Descriptors	Definition	Scale	Test mode
Color	Sensation perceived with the naked eye	1: white 5: straw yellow	Visible
Odor	Sensation to the smell	1: not pleasant 5: extremely pleasant	To the smell
Fibrous	Contains fibers	1: not fibrous 5: extremely fibrous	Visible
Texture	Manifestation of structural and mechanical properties		Visible / to touch
Homogeneous	Contains grains of the same size no lumps	1: not homogeneous 5: extremely homogeneous	Visible To sight / to touch
Friable	Suitability grains that can be detached easily	1: not friable 5: extremely friable	To the touch To the touch
Consistency	Degree of solidity	1: not consistent 5: extremely consistent	In the mouth
Taste	Degree of flavor perception		In the mouth
Sour	Taste on the tongue associated with an acidic fermented product	1: not sour 5: extremely sour	In the mouth
Sweet	Taste on the palate tongue associated with sugars (sucrose, fructose).	1: not sweet 5: extremely sweet	In the mouth
Overall assessment	Rating of the organoleptic quality of the <i>attiéké</i>	1: very bad 5: very good	In the mouth

Statistical Analyzes

The statistical analysis made it possible to assess the influence of the harvest stage, on each of the parameters studied using the analysis of principal components (PCA), to verify the existence of differences between all the characteristics of the *attiéké* studied. depending on the stage of harvest. The heatmap (frequency map), on the other hand, matched the intensity of each variable quantity to a color chart on a two-dimensional matrix. It made it possible to make an ascending classification of the components to highlight the observed differences, by grouping them in class. Thus, these two R 4.0.2 software methods made it possible to identify the harvest stage favorable to obtaining products of good sensory quality.

Results and Discussion

Sensory Properties of *Attiéké*

The descriptive test was carried out to find and quantify the descriptors of *attiéké*. While the hedonic test, was carried out in order to know the overall assessment of the *attiéké* according to the stage of harvesting the cassava roots studied by the panelists. The averages of the descriptive and hedonic data obtained allow us to obtain Figures 2.

The pale yellow color of the *attiéké* was highly appreciated by the panelists. This whatever the stage of harvesting of the roots (Figure 2).

Regarding the smell, it was moderately pleasant for the *attiéké* resulting from the transformation of the cassava roots obtained in the eleventh month of harvest before becoming very pleasant from the twelfth month of harvest (Figures 2).

The *attiéké* was not sweet in the eleventh month of harvest. But, from the twelfth month of harvest, the panelists found it not very sweet (Figures 2).

The *attiéké* produced in the fourteenth month of harvesting the processed roots was judged to be more sour by the panelists (Figures 2).

The *attiéké* was moderately consistent according to the panelists from the eleventh to the fourteenth month of harvesting the roots used (Figures 2).

The *attiéké* which was not fibrous before the twelfth month of harvesting the roots used, became according to the panelists little fibrous after this stage (Figures 2).

The panelists judged the *attiéké* obtained after transformation of the roots to be not very friable from the eleventh to the twelfth month, before becoming moderately friable from the thirteenth to the fourteenth month of harvesting the cassava roots (Figure 2).

The *attiéké* produced in the twelfth month of harvesting from the transformed roots was judged to be more homogeneous by the panelists (Figures 2).

The *attiéké* produced was highly appreciated by the panelists in the twelfth month of harvesting the roots (Figures 2).

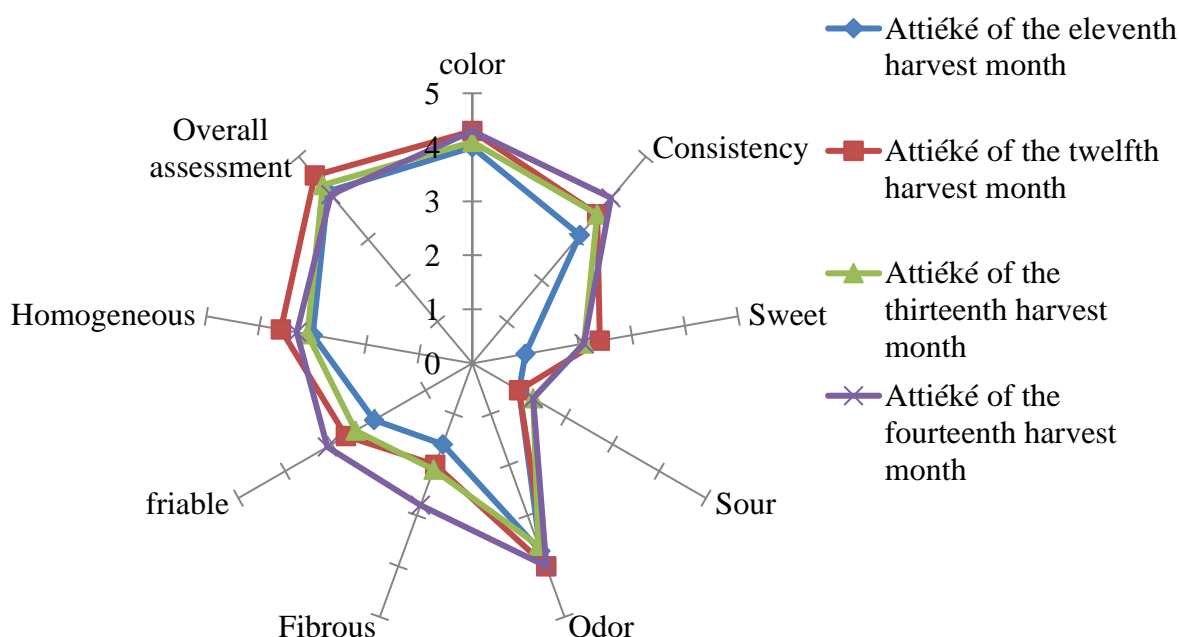


Figure 2. organoleptic properties of *attiéké* prepared with cassava roots of the Yacé variety harvested at different stages of maturity

Multiple factor analysis of the sensory characteristics of the *attiéké*

Principal component analysis (PCA) was done to better characterize the *attiéké*. Figures 3 represent the sensory profiles of the *attiéké* according to the stage of harvest given by the PCA. It emerges from this analysis that the four stages of harvest make it possible to produce types of *attiéké* which have different characteristics (Figure 3). To determine the variables underlying these differences, an ascending hierarchical heatmap classification, with a three-point scale (-1 = extremely low, 0 = acceptable, 1 = extremely high), was carried out (Figure 4). This classification made it possible to group the types of *attiéké* from the different stages of harvest into two main classes (I and II). The differences observed between the two types of class I *attiéké* are greater than those observed between the two types of class II *attiéké*. Class I of the heatmap of the components of the *attiéké* consists of the *attiéké* produced in the eleventh and twelfth months of harvest. While that of class II consists of the *attiéké* produced in the thirteenth and fourteenth months of harvest. However, the *attiéké* from the twelfth harvest month was very popular overall because it was consistent, less sour, less fibrous, more homogeneous with a better smell compared to those of class II and the eleventh month of harvest.

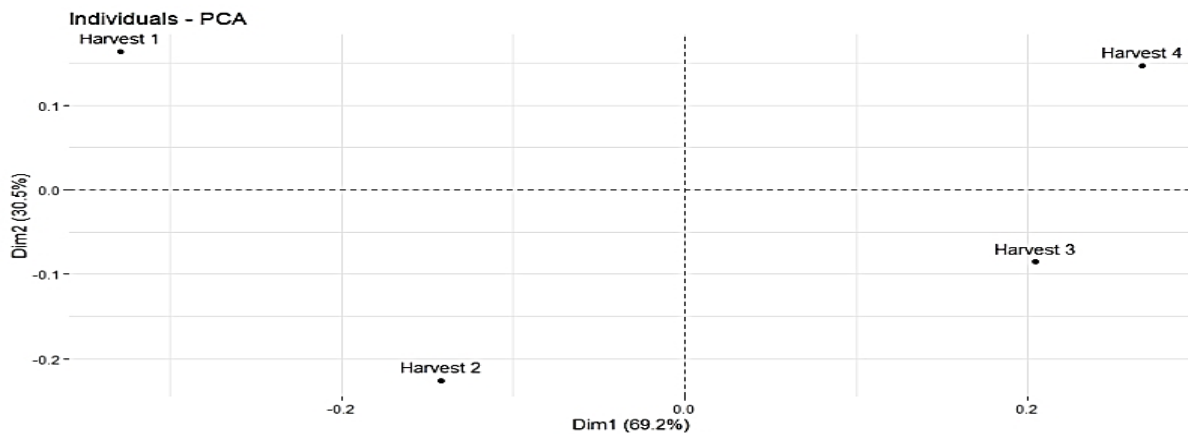


Figure 3. analysis of the main components of *attiéké* according to the month of harvest

Harvest 1: eleventh month of harvest; Harvest 2: twelfth month of harvest; Harvest 3: thirteenth month of harvest 3; Harvest 4: fourteenth month of harvest

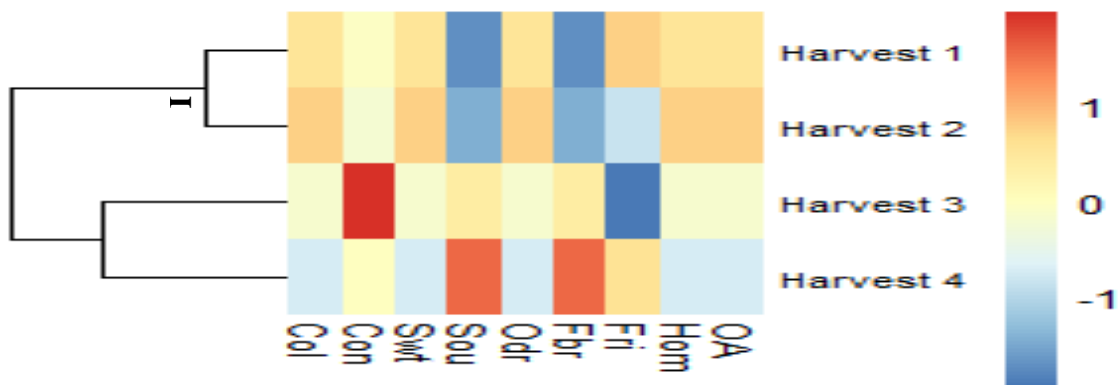


Figure 4. heatmap of the components of *attiéké* produced from cassava roots of the Yacé variety harvested at different stages of maturity

Harvest 1: eleventh month of harvest; Harvest 2: twelfth month of harvest; Harvest 3: thirteenth month of harvest 3;

Harvest 4: fourteenth month of harvest; Col: color; Con: consistency; Swt: sweet; Sou: sour; Odr: odor; Fbr: fibrous;

Ela: elastic; Hom: Homogeneous; OA: overall assessment

The analysis of the principal components showed that the *attiéké* obtained at the four stages of harvesting cassava roots has different characteristics because they do not appear in the same dimensional plans. The differences observed between the two types of Class 1 *attiéké* are greater than those observed between the two types of Class 2 *attiéké* depending on the distance between the point of insertion and separation. Since smell and taste are quality criteria (Pokou, 2006), these attributes influence its acceptability with the appearance of the product (Soro et al., 2013). *Attiéké* produced from the twelfth month of harvest, more generally appreciated by panelists because of its smell and taste, can be recommended to consumers. This smell and taste, appreciated by the panelists, is due to lactic acid bacteria, the main agents of the heterolactic fermentation of cassava roots which contribute to the texture and flavor of foods as well as to the production of aromatic compounds (Piard and Desmazeaud, 1992). Thus, this high acidity contributes to the formation of the sour taste of foods derived from the fermented pulp of cassava which is very popular with consumers (Toka and Dago, 2003). Also, the *attiéké* produced in the twelfth month of harvest was very popular because it was very homogeneous, consistent, crumbly and less sour with a good smell. According to the work carried out by Djéni et al. (2010), *attiéké* is well accepted by consumers when it is less sour, with homogeneous grains and a pleasant smell. However, the results of this study corroborate those of Yéboué et al. (2017), carried out during the sensory analysis of *attiéké*. These authors observed during their work that the *attiéké* was less sour, less acidic and homogeneous

Conclusion

This study consisted in determining the sensory characteristics of *attiéké* obtained from cassava roots. It appears that the *attiéké* obtained in the twelfth month of harvest presented the best sensory characteristics. At this stage, the *attiéké* was less sour, less acidic, less fibrous and homogeneous. Thus, we can recommend this stage to processors of cassava roots in *attiéké* for a qualitative improvement of their products.

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