

Report on the Status of *Attiéké* Production in Côte d'Ivoire

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Executive Summary

A project was assigned to IITA to evaluate the potential of *attiéké* steam-cooking to preserve the carotenoids of biofortified cassava roots and to develop an *attiéké* steam-cooker, based on the traditional cooker. An extensive literature search was followed by a field trip to Abidjan to acquire information from local processors on the production of *attiéké* and the various unit operations involved in processing, with the emphasis on steaming. The aim was to develop an improved, energy efficient, and affordable steamer to replace the existing traditional type. The team visited the Université Nangui Abrogoua Coccodi, three *attiéké* processing centers (Brofodume, Akardio, and Ananeraie, situated around Abidjan and the Coastal areas), the Société Ivoirienne de Technologie Tropicale (I2T), and a machine fabricator (l'Equipementier National), and held discussions with processors, their staff, and other officials. The main findings of the team are as follows: cassava is the third most important food crop after yam and rice; the main food items from cassava in Côte d'Ivoire are fresh roots, *cassettes*, *placali*, starch, tapioca, *garba*, and *attiéké*. Their cycles of production were studied and reported. A lot of research work has been done on *attiéké* processing and quality improvement but little or none on the steam-cooking method. All processing centers use traditional steamers. Three types had been introduced over the years by different projects: (1) gas-fired, (2) gas-fired multiple bay, and (3) rectangular or channel type. Attempts to introduce new kinds failed as all were rejected. The causes for these failures were compiled and listed here as the information received from processors. The present study concluded with the design and construction of a steamer that tries as much as possible not to repeat the mistakes of those previously introduced.



Source: Wikimedia Commons

Acronyms and Abbreviations

Biodiversity	Biodiversity International
CIAT	International Center for Tropical Agriculture
CIP	International Potato Center
CIRAD	Centre de Coopération Internationale en Recherche Agronomique pour le Développement, France
CRP RTB	CGIAR Research Program on Roots, Tubers and Bananas
FAO	Food and Agricultural Organization of the United Nations
FAOSTAT	Food and Agriculture Organization Statistical Databases
I2T	Société Ivoirienne de Technologie Tropicale (I2T),
ILRI	International Livestock Research Institute
IITA	International Institute of Tropical Agriculture
R&D	Research and Development
RTI	Radio Television Ivoirienne

Background and Introduction

The CGIAR Research Program (CRP) on Roots, Tubers, and Bananas (RTB) is led by the International Potato Center (CIP) and brings together the RTB crop-related work of CIP, Bioversity International, the International Center for Tropical Agriculture (CIAT), the International Institute of Tropical Agriculture (IITA), and CIRAD, the French organization for agricultural research and international cooperation, as well as about 300 other partners (RTB Report 2016). RTB aims to realize more fully the potential of RTB crops for improving nutrition, income generation, and food security—especially among some of the world’s poorest and most vulnerable populations.

The crops are banana/plantain, cassava, potato, sweet potato, yam, and other tropical and Andean roots and tubers—sometimes termed vegetatively propagated staple crops.

During 2012, the RTB CRP resulted in unprecedented interaction among participating CGIAR centers, IITA, CIP, CIAT, and Bioversity, to produce an integrated research program that benefits from the synergies of collaboration. This organization provided a good starting point, bringing together research on five primary crops (banana/plantain, cassava, yam, potato, and sweet potato) and several minor tubers. The organizational framework resulted in the creation of new cross-cutting initiatives involving multiple crops and multiple centers. An example of these cross-cutting initiatives is the present study by CIAT and IITA to help address the improvement of cassava processing.

These two institutes have put up a team to address this issue, the design and construction of an improved steamer that can be used traditionally in Côte d’Ivoire to cook *garba*, and *attiéké*. These two major food items, consumed twice, and even three times daily in this country by the majority of the population, are also fast gaining ground in West Africa, Europe, and America.



Source: Wikimedia Commons

About the country

The Republic of Côte d'Ivoire is located in [West Africa \(8 00°N, 5 00°W\)](#) with a population of 25,083,505 (0.33% of the world's population) and ranks number 53 by population in the list of the world's countries. The total land area is 318,000 km² (about the size of Germany) with a population density estimated at 78/km² according to the UN. The birth rate is 29.25/1000; infant mortality rate: 60.16/1000, and life expectancy: 58.0 years. The political capital is [Yamoussoukro](#) (with a population of 0.966 million); the economic capital and largest city is the port city of [Abidjan](#) (population 4.288 million). The country borders [Guinea](#) and [Liberia](#) to the west, [Burkina Faso](#) and [Mali](#) to the north, [Ghana](#) to the east, and the [Gulf of Guinea](#) (Atlantic Ocean) to the south (Côte d'Ivoire Country Profile 2014).

Côte d'Ivoire was initially made up of numerous isolated settlements; today it represents more than 60 distinct tribes, including the Baoule, Bete, Senoufou, Agni, Malinke, Dan, and Lobi. In 1842, the French obtained territorial concessions from local tribes, gradually extending their influence along the coast and inland. The area was organized as a territory in 1893, became an autonomous republic in the French Union after World War II, and achieved independence on 7 August 1960. The nation's economy is one of the most developed in sub-Saharan Africa. It is the world's largest exporter of cocoa and one of the largest exporters of coffee.



Source: Wikimedia Commons



Plate 1. Map of Côte d'Ivoire. (Source: Republic of Côte d'Ivoire. Accelerating 2030 Agenda, April 2018).

Cassava in Côte d'Ivoire

Manihot esculenta, commonly called cassava, manioc, or yuca, is extensively cultivated as an annual crop in tropical and subtropical regions for its edible starchy tuberous roots, a significant source of carbohydrates. According to Mendez et al. (2017), the production of cassava is recent in Côte d'Ivoire. It was introduced by migrating populations, notably the Aboure and Aladjan ethnic groups. Its production started from the littoral East to now cover the whole country. Its production is unevenly distributed; the main producing zones are the Center, South, and West-Central. San Pedro in the lagoon zones follows with a third of the production in the South-West and Aboisso in the South-East (Mendez et al. 2017). For some time now, pushed by industrial crops, cassava cultivation has been gradually moving from the South to the Center in the regions of Gbeke and Belier and towards the West-Central zone.

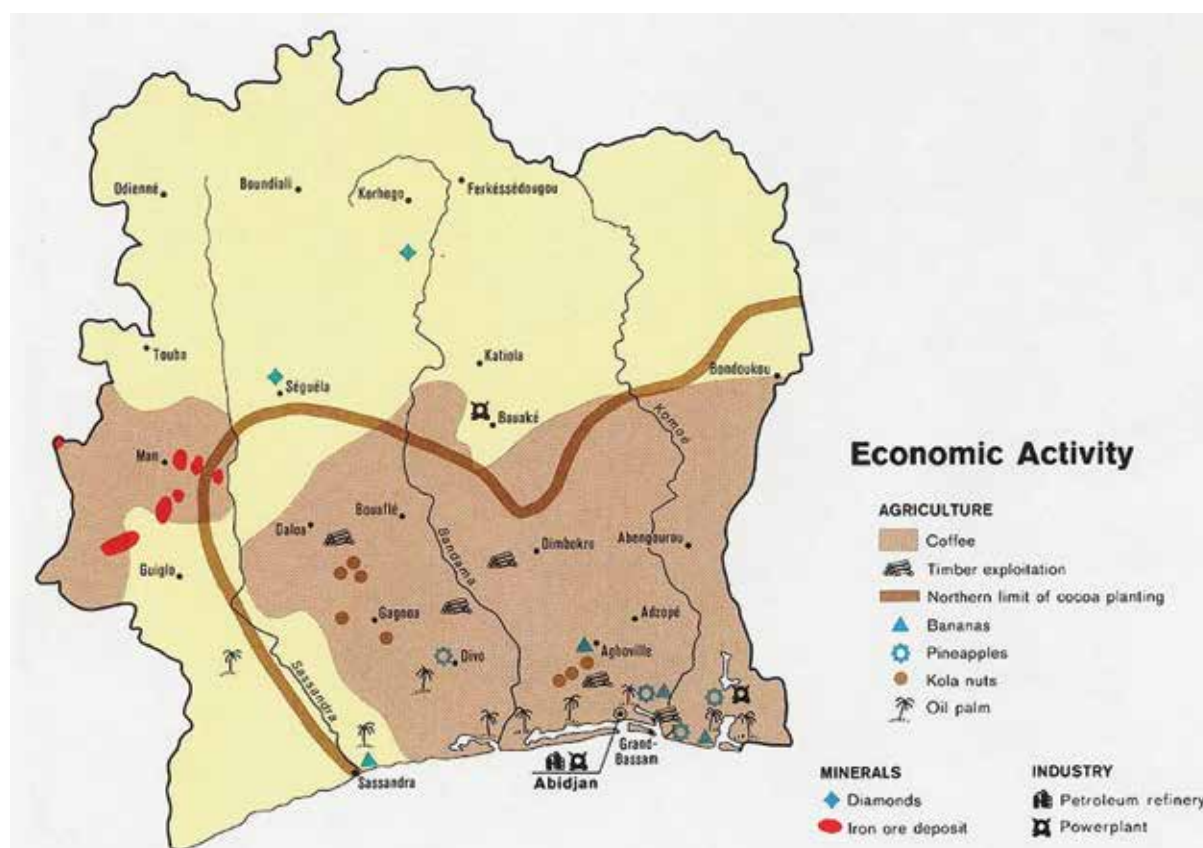


Plate 2. Main cassava cultivation areas in Côte d'Ivoire. (Source: Côte d'Ivoire Country Profile 2014).

Until recently in Côte d'Ivoire, following the example of many other countries that cultivate this crop, cassava was the food of the poor, meant just to be eaten during famine times; it was usually sold fresh by short distribution channels. Today, cassava has acquired national and international dimensions with opportunities for more income for the rural population.

Production has been increasing continually (Fig. 1) with an annual increase of 104% (FAOSTAT 2017). According to the country's international TV program, RTI "Made in Africa (2018)", the Government plans to produce 8 million t by 2020 which will represent an increase of 249% in 4 years from 2016.

Data on quantities produced by regions in Côte d'Ivoire were not available, but the study conducted by Mendez et al. (2017) states that cassava is cultivated all over the country and that the main producing zones are those located in the forest areas where rainfall is higher. The same study states that production is low in the North (Korhogo); production increases from the North to the South and

increases further around densely populated areas (Abidjan, Yamoussoukro, Bouake, Daloa, San Pedro, Duekoue). Climatic constraints and low yields have not affected cultivation (Fig. 1).

Figure 1, compiled from FAO data (2017), shows that cassava cultivation in Côte d'Ivoire has been increasing constantly with a 7-fold growth within 55 years. But this expansion is related more to the increase in farming areas than to an increase in productivity (Fig. 2).

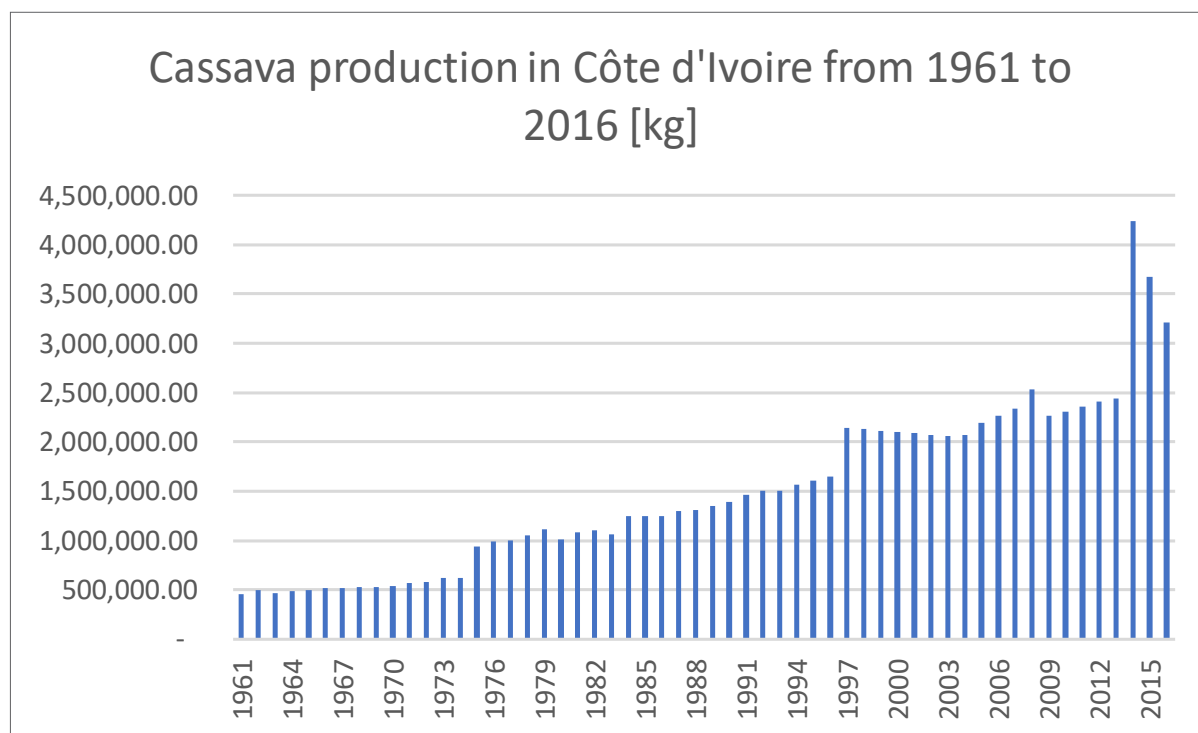


Figure 1. Côte d'Ivoire cassava production from 1961 to 2016 (FAO data 2017).

Source: FAOSTAT 2017.

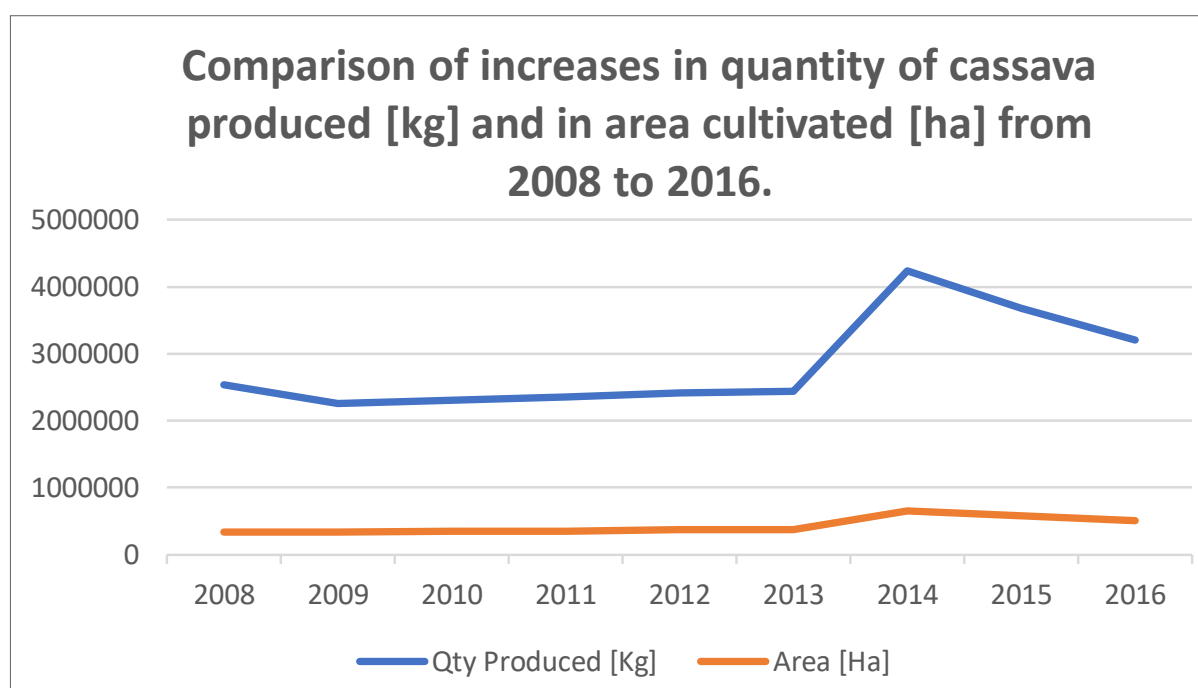


Figure 2. Cassava production quantity and area cultivated from 2008 to 2016.

Source: FAOSTAT 2017.

Official statistics put the yield at 9 t/ha. Certainly improved varieties, better agronomic practices, and improved farmers' organization can raise this yield to 10 and even 20 t/ha as suggested by Mendez et al. (2017) and compared to our experience in Nigeria where IITA farmers have been able to obtain 25 to 30 t/ha against the (Nigerian) national average of 10 t/ha, with 45 to 50 t/ha in the research fields.

IITA has been assisting Côte d'Ivoire with improved varieties and demonstration plots. However, this needs to be documented and followed up; there might need to see how IITA's developed varieties compare with local cultivars in Côte d'Ivoire and with those being bred by local research institutes.

Forms of organization of processing centers

This study, which focused on the design and construction of a steamer for *attiéké* production, covered various types of processing centers and included interviews with actors, surveys of processing places, observations on tools, and the way operations were being conducted on the days of the visits. The stay in each center was not long enough to fully understand the whole process, such as time lengths, materials' balance, what will change if one aspect or another is broken, etc. However, it was enough to add to the knowledge acquired from the extensive literature and the experience gathered here in Nigeria on cassava processing. Below is the summary of the findings from the field trip and the fruit of these observations.

The processing centers can be divided into three main classes.

Family or neighborhood processing centers

Akradio center, which we visited, is a processing center of this type; we can call them more accurately improved traditional processing centers. They process the cassava from their own farms and from the farms of their members. They also buy from farmers; at times they get contracts or people with contracts come with cassava for them to process into any of the products but especially *placali* and/or *garba*. In these centers, every operation is carried out in an open place; they do not have buildings; all machines are manual and very close to the traditional ones. **Sorting and peeling** areas are combined; peeling and cutting are done manually. **Grating/rasping** is often contracted out. Members have a steamer in stock, with the tools used to operate it; they may also have granulation tools, drying pans, and fanning instruments in common; all these tools are manually operated. Members often have their presses and knives. During processing, each member is expected to bring their tool(s) for use.

At times, members work in the compounds of colleagues that have steamers on a turn-by-turn basis or members converge on these places with their tools and work together. Less well-equipped groups meet at the Chairperson's compound to work, or in an area located not far from a stream, or where water from the national grid is available.

The tools they use are bought or acquired by the members, not gifts from projects; it seems that these centers struggle. All the equipment is small and manually operated except the grating operation, which is either done manually on wood and perforated sheets or contracted out to a local mill. The center visited (Akradio) had a service provider that they pay in kind for grating by giving the owner of the grater a certain quantity of the cassava pulp. Some service providers make money, but since money is not easy to find in such remote places, payment is often in kind, using the grated pulp. Centers of this kind make three types (*attiéké*, *garba*, and *agbojama*) of product. One thing to note is that in these centers all the equipment is being used; there is no idle machine.

The production is based on job orders or relies on relations in prominent places with many consumers to sell their final products. The members at Akradio, relied on their sisters in Abidjan; they hardly ever have big contracts.

Associations and/or cooperative processing centers

These centers, such as those we saw at Brofodume and Yopougon Ananeraie, have more members; they are bigger than the neighborhood groups and have structured buildings. They have more and better equipment that is usually given to them by projects (NGOs, Local Government/Districts, etc.). We can call them semi-mechanized centers. They have water and electricity and do not contract work outside as they have all the facilities. They process the cassava from their own farm and from their members. They also buy from outside; many of them have a few farmers they call on to supply roots to order. At times, these centers get contracts or people with contracts come to them with cassava for them to process into any of the products. People having parties in town (weddings, etc.) come and book. That was what happened during the visit to Yopougon Ananeraie.

It is good to get equipment from projects, but at times this can be the wrong kind of equipment, especially if the technology being transferred is not yet mature. Along that line, during our tour, a biogas facility was seen and was expected to generate burnable gases for use in the processing center, but the facility never worked. Gas-fired steamers, continuous steamers, and a solar dryer were seen in other locations but were all put aside or dropped, and the cooperatives continued to work in the traditional ways. Technical faults, limited use, and cost of operation were given as reasons for these abandoned facilities/machines. At times also, a lack of maintenance was the only cause of equipment/facility being put aside. An example was a solar dryer that was no longer used because of a partly torn tent and the effects of erosion. Proactive management could have attended to both problems.

There is a need to make the members aware that these items of equipment, although given by projects and authorities, belong to them and they need to take care of them. There is also need to train some of the staff on the maintenance of these facilities.

Members are mostly women educated to secondary school level; they speak the French language well, are mothers of children, etc.

Mechanized processing centers

We did not visit a mechanized processing center for *attiéké*. We were told about them, located in the Central part of the country, but we could not visit them. It seems they are privately owned and make dried products.

Others

We saw efforts to develop machines at I2T and Equipementier National, two R&D and machine building establishments, one private (Equipementier) and one public (I2T). We saw peeling machines, graters, and steamers under development. It was in these establishments that we were told about the existence of the privately owned, mechanized processing centers. A documentary from the country's international TV program, RTI "Made in Africa 2018" also had an excerpt on these factories.

Information on the processing centers

During this study, we read some of the literature, visited three types of processing center, distributed and administered questionnaires, and carried out focus group discussions.

The following is the summary of the findings on the makeup and operation of the processing centers, the products they make, and how they distribute them.

Make-up of the processing centers

Our team visited three cassava processing centers, one machine development center, and one fabricator. We also consulted the literature on how cassava is processed in Côte d' Ivoire.

Table 1. General Information about processing centers.

	Names of processing centers visited		
	Brofodume	Akradio	Ananeraie
Year established	2015	2014	2012
Headed by	Female	Female	Female
Type of center	Semi-mechanized/ cooperative	Cottage improved, Family/ neighborhood	Semi-mechanized/ cooperative
Number of people	53 females and 7 males	18, all females	66 females as of 2012, no males
Permanent workers	60	18	N/C (Not captured)
How they are paid	Cash by sharing profits on each single operation by the Cooperative	Cash by sharing 1/4 of annual profits at the end of each year	N/C
The best way of work	Can have more equipment and meet bigger demand.	Best to have common cassava farms	N/C

Source: Field trip, 2018.

All the processing centers visited were established after 2014; they were all headed by women and had a male percentage between 0 (Akradio) and 13% (Brofodume). Thus, women handle the processing. All workers were permanent, there were no casual laborers, and all are paid from the profits made on a single operation in the Cooperative or Association type of centers and at the end of the year in the family/neighborhood or cottage/communal type. Cooperatives usually have a more significant number of workers (60) compared with the cottage type (18). They differ in thinking concerning the best way of working, but all agree that working together is better than working alone. Cottage types believe the best way to work is to have a collective farm while Cooperatives see togetherness as a way to get more equipment and have access to bigger orders.

Look and structure of processing centers

Table 2. Types of building structure of processing centers.

	Names of Processing Centers visited		
	Brofodume	Akradio	Ananeraie
Description of Center	Clean, has water from village borehole and the streams	Clean, has water from the national grid and the streams	Clean, has water from village borehole and the streams
Structure	Excellent building with walls, roof, cemented floor, tiled in places, fenced, entrance gate, good layout	No structures, no building, it is an open place in front of the house of a member or the Chairperson	Excellent building with walls, roof, cemented floor, tiled in areas, fenced, entrance gate, good layout. Much more equipment

Source: Field trip, 2018.

All three processing outfits visited have a similar layout. Areas are demarcated for specific operations. During our visits, we found the following areas for different stages: Reception, Peeling, Pressing, Sun-Drying, Fanning, and Steaming. Buildings and structures of processing centers differ from one type to another. Cottage/family and neighborhood types tend not to have any building structure; they operate in an open place in front of members' houses on a turn-by-turn basis or in the yard of the Chairperson. Cooperatives, on the contrary, have expansive structures with a roof and proper demarcation. Both types of center are very clean, have access to water from the grid, or boreholes of villages or cities, and often water from streams in case the grid or borehole fails.

Types of *attiéké* produced

Table 3. Different types of *attiéké* produced in Côte d'Ivoire.

	Names of processing centers visited		
	Brofodume	Akradio	Ananeraie
Type produced	All three types: <i>agbojama</i> , regular, and <i>garba</i>	Normal	Not captured (N/C)
Prices [CFA/kg]			N/C
Agbojama	800	N/C	N/C
Normal	600	N/C	N/C
Garba	500	N/C	N/C

Source: Field trip, 2018.

Respondents from all the centers listed three types of *attiéké* product. According to them: these were normal, *agbojama*, and *garba* without explaining the differences between them. This differentiation seems to be accepted by everybody. All the types of centers may have the capability to make all three types, but only Brofodume claimed to be doing all three according to orders it receives. Akradio said it makes only regular *attiéké* (the best, they added). Ananeraie could be in the range of Brofodume as they are in the same range of centers (semi-mechanized/cooperative type), but no interview was conducted: we just visited the premises.

Equipment in use by type of center

Table 4. Equipment in use by type of processing center.

Stages of Processing	Names of processing centers visited		
	Brofodume	Akradio	Ananeraie
Reception and Sorting out	In an open place	In an open place	Under shade
Measuring/Weighing	Open place, use of scales and buckets	Open place, use of buckets	Open place, use of scales and buckets
Peeling and cutting	Knives	Knives	Knives
Grating	Two machines. One was given as a loan from a project, but that machine was found slow, so the Coop bought a second grater. The two tools are being used.	No grater available, These centers used a service provider	One grater available
Fermenting	No mention	In buckets for 12 h	Inside buckets
Pressing	One big press from I2T, 2015, but it was found slow and the Coop, using their own money, bought a second press.	Small screw presses from members. Each member has her press, the small size type	Twelve small screw presses available. The source was not captured
Granulating	Two machines. One as a loan from the project but it is slow. Then the Coop, using their money, bought a second one. Both are in use	Use of traditional tools with manual granulation	One granulator and tools
Sifting	Traditional sieves	Traditional sieves	Traditional sieves
Steaming	Got a number of them from projects. None has been working fine. 1 unit of 3 steamers, gas-fired, was found expensive and put aside; 1 continuous type of steamer from the project did not work at all. Center has now returned to traditional steamers.	One traditional steamer	Two steamers were seen being used. The center had eight spots for traditional steamers
Using Biogas	No	No	Available but not working
Using Solar dryer	Concrete floor; 1 Solar tent dryer not in use.	Sheets of plastic and traditional kind (wooden mats, circular bowls)	Concrete floor

Source: Field trip, 2018.

Centers were well equipped to carry out their jobs, but the whole work seems aimed at small-scale production. Machines used are small-scale types except for the grater. To them, it looks as if any increase in production can be done only through an increase in the number of small machines.

Sources of machines differed according to type of center:

Cottage/family and neighborhood centers tended to have their tools owned by individual members. They would bring their tools to the place to work that day but would use external service providers for grating.

Cooperatives mostly have machines given to them by projects, but at times they will buy tools to reinforce the existing ones or to replace the machines given to them by projects when they find these machines slow or unsuitable.

Peeling and sieving are done manually for all types of centers. Fermentation is in buckets. Pressing is done using small presses. Although I2T has introduced a granulator, granulation is mostly done using traditional tools. Only cooperatives can afford a mechanical granulator.

Sources of cassava roots

The study dealt with the sources of cassava roots. The findings are compiled in Table 5.

Table 5. Cassava farms and relationship with cassava farmers.

	Names of processing centers visited		
	Brofodume	Akradio	Ananeraie
This center works with cassava farmers	Yes; their members or separate farmers	Yes; their own members or separate farmers	(Not captured) N/C
Do you have registered farmers?	No	No	N/C
How many farmers are in your area?	If we have big orders, four farmers are contacted	None	N/C
Do you own a farm?	Yes, 4 ha	Yes, 1 ha	N/C
Quantity produced			N/C
2016	No records	800 balls	N/C
2017	No records	800 balls	N/C
2018	No records	No orders received	N/C

Source: Field trip, 2018.

All respondents worked with cassava farmers; the farmers in question could be processing centers' own members or independent farmers not registered with the centers. The working relations can be summarized as ordering a load of cassava roots, paying, and getting the delivery. The buyer pays the transport; usually, motorbikes equipped with trailers are used. Cassava farmers live in the vicinity, not because of the processing center but as neighbors or members of the community. All types of processing center were found to have their cassava farm; it could be significant (up to 4 ha) as in the case of semi-mechanized centers or small (around 1 ha) for the cottage type of processing, but it looks as if this is a condition for the existence of the center.



Plate 3. The arrival of a motorbike carrying cassava roots at Brofodume.

Source: Field trip, 2018.

Also, members have their cassava farms. The quantity of cassava produced was confused with the amount of *attiéké* produced and reported by the cottage processing center as 800 balls/month; a ball of *attiéké* is about 0.86 kg which put the yearly production capacity to be 688 kg of *attiéké*/month but because of inadequate knowledge of record keeping (oral), the data provided is just indicative.

Processing of cassava in Côte d'Ivoire

The study identified six products in addition to fresh roots: *cossettes*, *placali*, *garba*, *attiéké*, *foufou*, and starch. The survey covered how these products are made, distributed, used.

Fresh cassava roots are fragile and have a short life span after harvesting owing to their rapid physiological decomposition (Martial et al. 2016) calling for processing within 48 hours after harvest. Processing aimed at removing the harmful chemical in the roots, preserving the useful characteristics, preparing the roots for human consumption or industrial use, making products with a longer shelf life, and easing and reducing the cost of transport. All these activities add value to the fresh roots.

Processing is accomplished by a series of physical, chemical, and biological operations. For now, most of these operations are carried out manually in Côte d'Ivoire resulting in variations and discrepancies in physical, chemical, and sensory qualities.

Each cassava product has its set of operations that can be summarized as follows and combined to make the final product.

Fresh roots

Fresh roots (both sweet and bitter) direct from the farm deteriorate within 48 hours. They are produced from different places (household farms, individual farms, family farms, association/cooperative farms, processing center' farms, out-grower farms, etc). The roots harvested from these farms are transported home for use or transformation. They can also be sold directly to markets (short circuits) or to middlemen/women or processing outfits. They must reach transformation places within 48 hours to avoid deterioration and loss. Around the world, there are many techniques for cassava root preservation, but the only one known by farmers in Côte d'Ivoire is to leave them unharvested in the farm, a practice that affects the cassava sector in humid zones with a lot of water in the soils.

The collection and transport activities are critical to the roots, the derived product, and the income of the actors. Roots must be collected from farms and transported to bulking places, then to the markets and the processing centers. Collection and transport are difficult to carry out because farms are scattered, roots are bulky, heavy, and perishable, and means of transport scarce. When harvesting of cassava coincides with the collection of a cash crop, the difficulties in getting transport are enormous. The conventional means of transport are shown in Table 6.

Table 6. Means of transport of cassava.

Means of transport	Capacity [kg]	Distances [km]	Actors
Head pan	40	0.5 to 1	Farmers and members of their household or association
Bicycle	Up to 130	1 to 5	Farmers and members of their households or association
Motorbike (Keke NAPEP type)	800	15 to 20	Farmers and members of their households or association; also, middlemen, the processing centers, or private service providers
Pick-up	2 to 2.2	Up to 70	Middlemen, processing centers that may own or rent or private service providers
Hilux pick-up	3 to 4	Up to 100	Middlemen, processing centers that may own or rent, or private service providers that provide transport services for a fee
Truck	10 to 15	100 and more	Middlemen, processing centers that may own or rent, or private service providers that provide transport services for a fee

Source: Adapted from Mendez de Villar (2017).

Some individual processing centers have their transport, others look for a service provider, but they all agree that it is ideal for them to have their own transport facilities.

The fresh cassava root flow can be summarized as shown in Plate 4 according to our study.

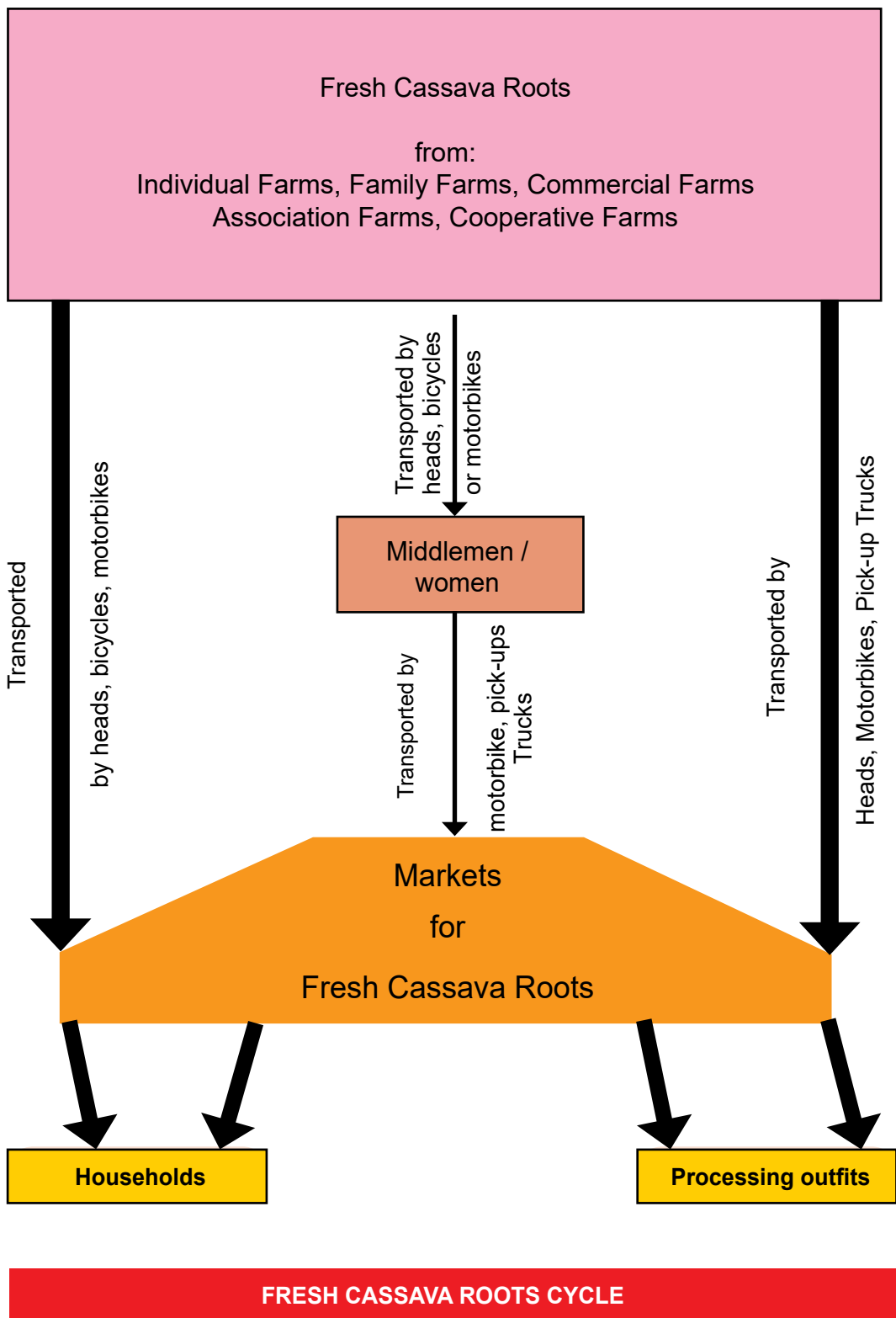


Plate 4. Fresh Cassava Roots Flow Chart.

Cossettes

Cossettes are dried cassava chips. They are at the lowest level of root processing. The processing flow chart is a simple one: fresh roots from farms (usually the sweet type, but sometimes bitter ones) are transported, received, sorted, peeled, cut to pieces, and dried in the sun or at times, specially built dryers. In other parts of the world, peeling is optional according to the final uses of the chips. *Cossettes* or dry cassava chips store easily and keep for over 12 months.

The process of obtaining *cossettes* in Côte d'Ivoire as found in the literature can be summarized as shown in Plate 5.

Cossettes have a longer shelf life than fresh cassava roots, so they serve as a means of preserving the fresh roots. They are used to make flour for human consumption and can be incorporated into animal feed or used for industrial applications. In Cote d'Ivoire, *cossettes* were used mostly only for human consumption.

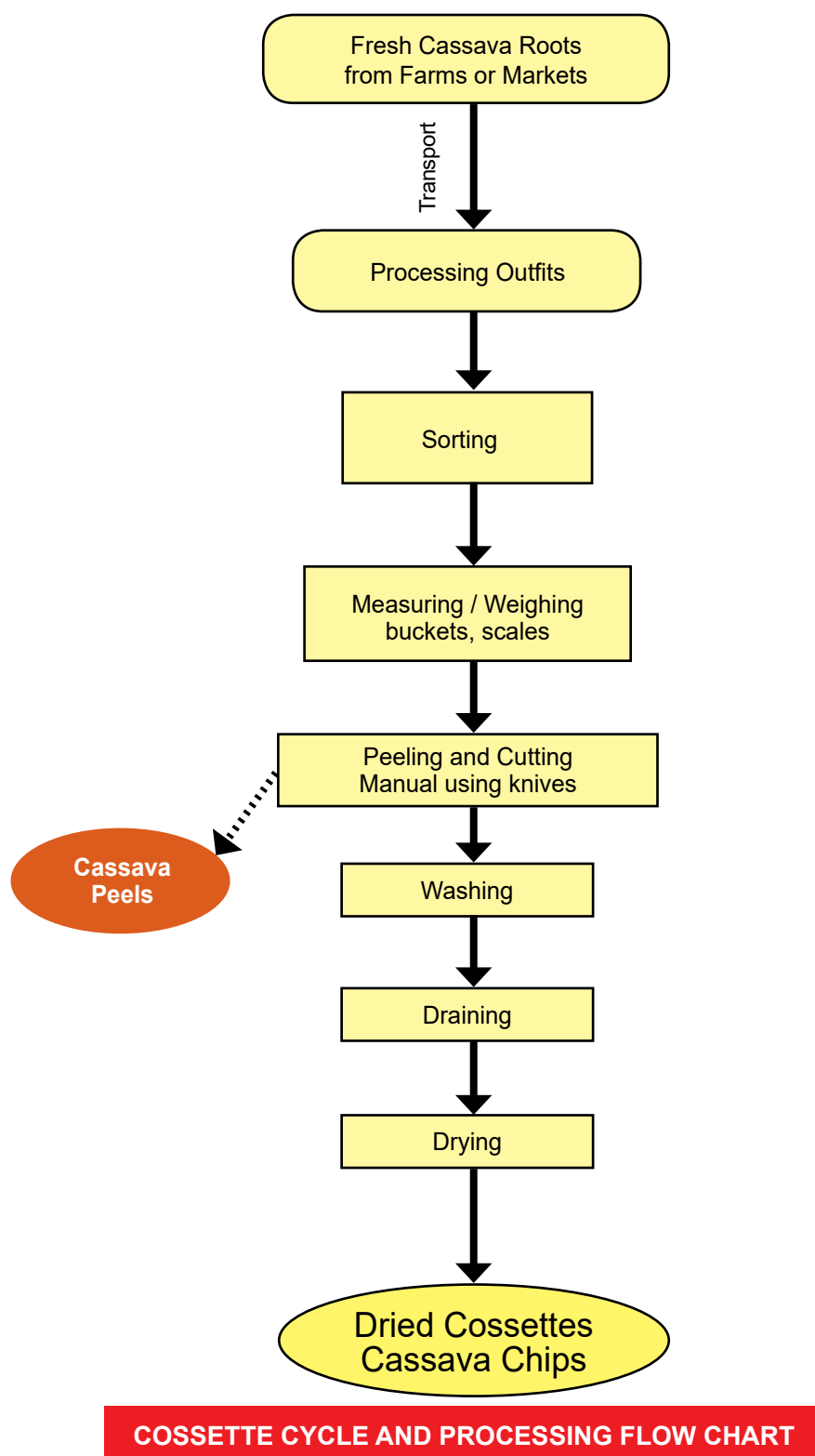


Plate 5. *Cossette* cycle and processing flow chart.

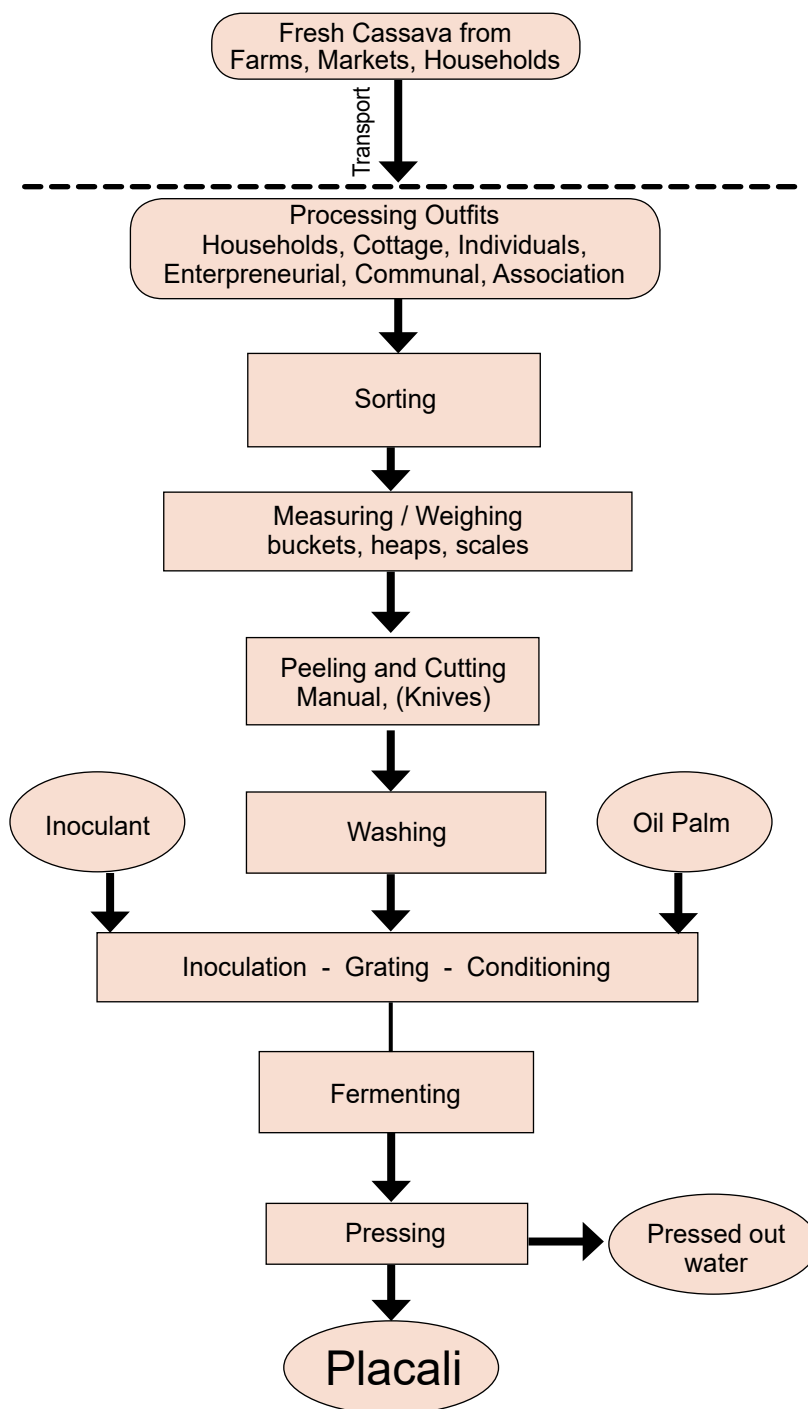
Placali

Originally, *placali* is a dough for household consumption obtained by slowly boiling and stirring fermented and sieved cassava paste in hot water. But in the present context, *placali*, as referred to, is not a food ready to eat, but a kind of pulp that is obtained after peeling, washing, rasping/grating into pulp, fermenting, and pressing. In Côte d'Ivoire, palm oil is added to the mix during rasping as shown in Plate 6. *Placali* keeps longer than fresh roots and is less bulky and heavy. It is just the basic raw material to produce *attiéké* and *garba*. In places far from farms with higher levels of consumption of cassava products, *placali* is a strategic product that reduces transportation costs and logistics and is a means to avoid spoilage of the roots during transport over very long distances. *Placali* helps increase the shelf life and reduces bulkiness, but on arrival, according to the distance, it will have higher levels of sourness and flavor.

Interestingly, there is a similar method of cassava paste preservation in Nigeria called *bukuru* in which fermented and pressed pulp is rolled into balls of the size of a football and roasted or oven dried. This method has not been sufficiently studied. During our fieldwork some years ago, we saw some *bukuru* balls being transported in Ago Owu in Ondo State. Mendez de Villar (2017) reported similar methods used in Vietnam and Colombia for preserving starch from cassava. These methods are not fully known to us here but could be suitable avenues for cheaply prolonging the useful life of cassava roots; these methods may preserve useful characteristics and reduce bulkiness. Studying them will not only add to or reviving knowledge but be a way of transferring technologies among cassava sector actors, be an additional source of income and other drivers of the sector value chain. The *placali* flow chart is shown in Plate 6.



Source: Wikimedia Commons



PLACALI/CYCLE AND PROCESSING FLOW CHART

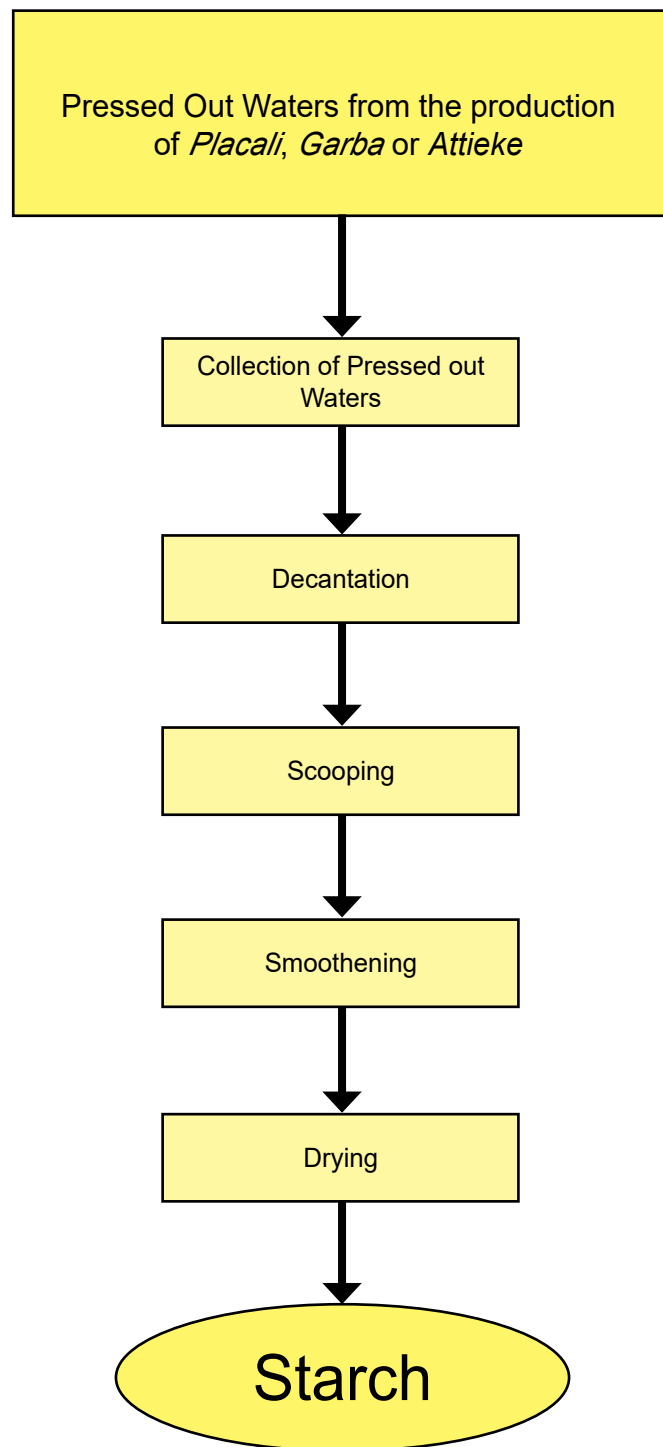
Plate 6. *Placali* cycle and processing flow chart.

Cassava starch

Starch is not a prominent product in Côte d'Ivoire despite its potential for food and industrial uses, and its essential role as a driver of production and creator of employment in rural areas. In Côte d'Ivoire, starch comes as a by-product during the production of *placali*, *attiéké*, or *garba*. This starch is obtained by collecting and decanting the liquids from pressing the fermented pulp. The production process is simple: the gathered waters are decanted, and the cake scooped, loosened/crumbled, and sun-dried as shown in Plate 7.

The quality of this starch can be useful, and it is used as tapioca or for laundry only. This starch has not attracted the big off-takers as happens in Nigeria or Brazil where large standalone factories

with capacities of 50 to 450 t of fresh roots/day are built to produce starch exclusively for food and beverage industries as well as breweries.



STARCH CYCLE AND PROCESSING FLOW CHART

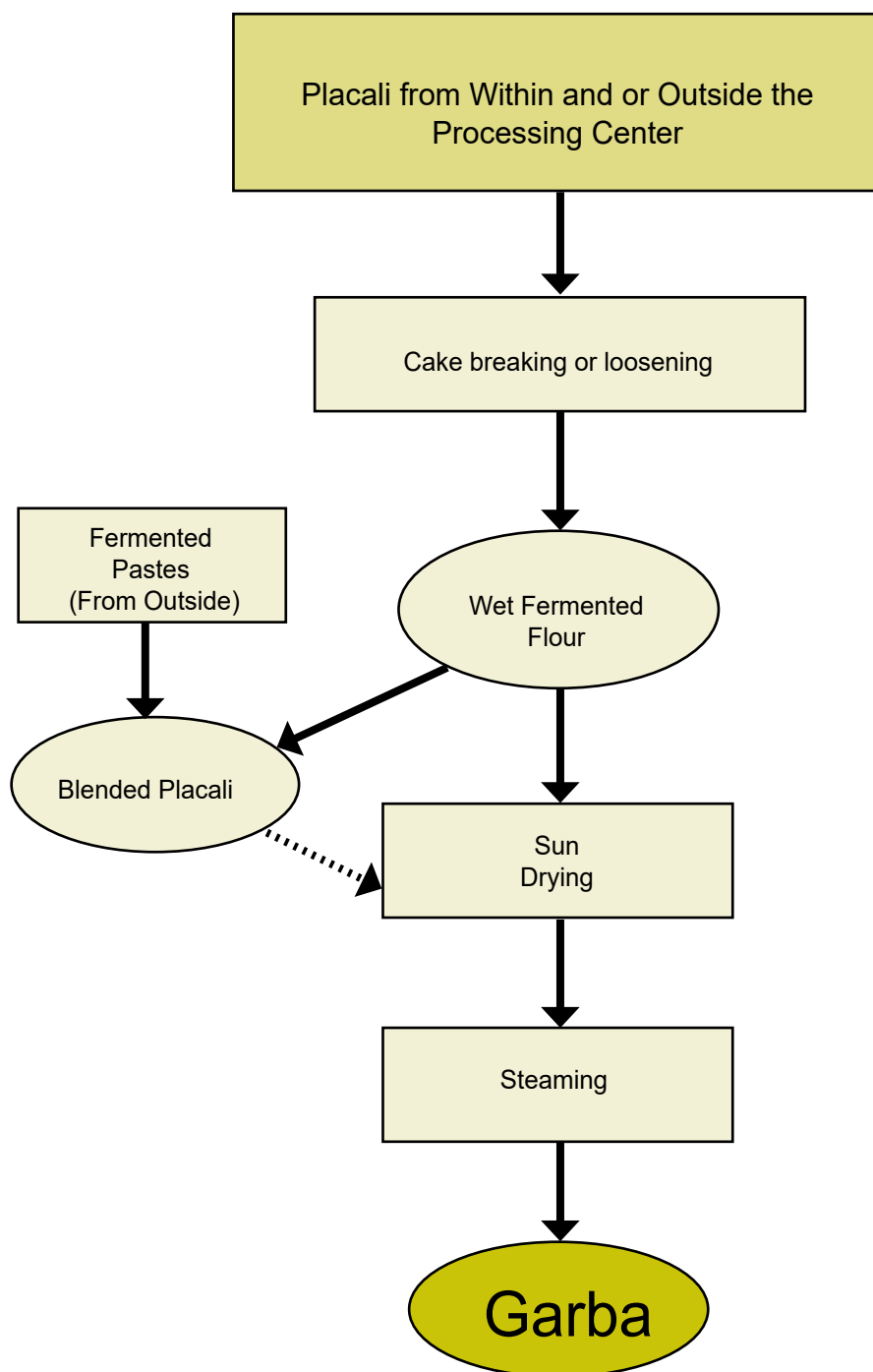
Plate 7. Starch cycle and processing flow chart.

Garba

Garba is obtained by steaming crumbled *placali* directly without fiber removal. So it is the important raw material (or only material) for *garba* production. *Placali* can come from within the same processing center, from faraway places, or just outside the processing center. If it has come from

outside, this paste can be blended (or not) with pressed cassava. Therefore, *garba* production includes all the operations to produce *placali* with the addition of cake crumbling, blending with other fermented loosened flour, drying, and steaming as shown in Plate 8.

Garba is a meal eaten with various sauces; it high in fiber, low in granules, and may have more pronounced flavor and aroma.



GARBA CYCLE AND PRODUCTION FLOW CHART

Plate 8. *Garba* cycle and processing flowchart.

Attiéké

Attiéké is a meal eaten directly with various sauces. It represents the highest level of processing of *placali*. Its production process includes all the operations of *placali* production with the addition of five other processing stages: Granulation, calibration, fanning, drying, and steaming as shown in Plate 9. The main difference from the production of *garba* is the addition of three operations (granulation, calibration, and fanning) that each enhance the quality of the product. So *attiéké* has less fiber than *garba*, has more uniform granules, and looks more like couscous.

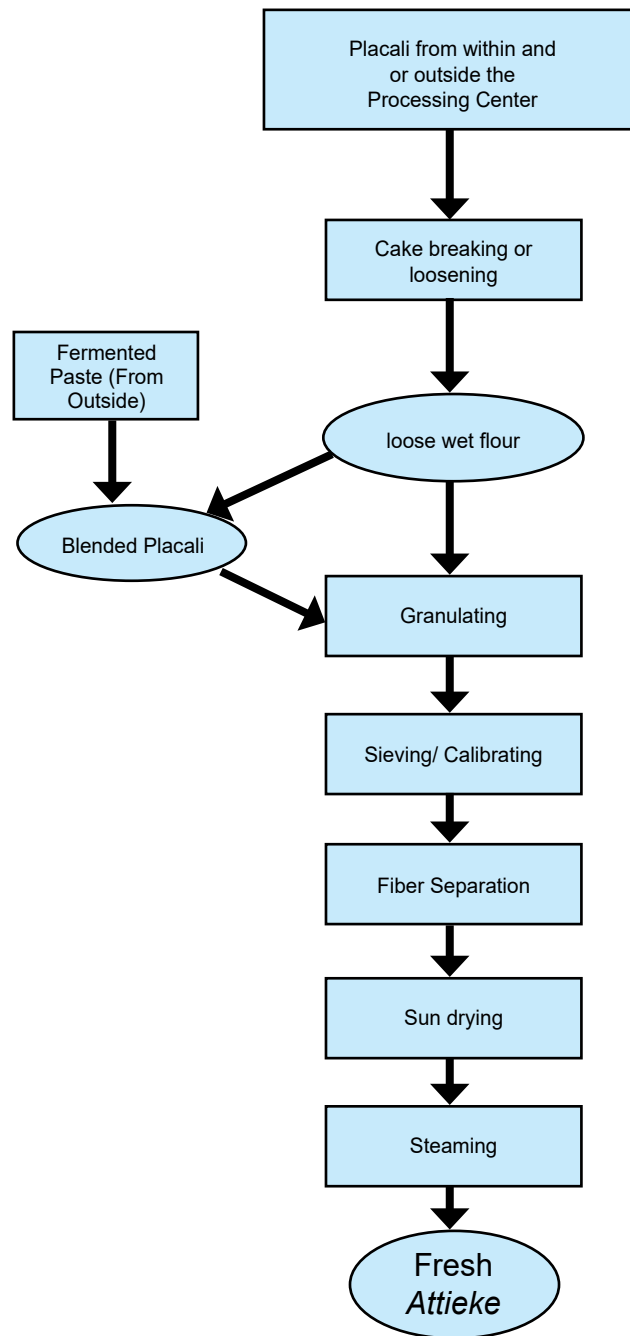
Studies on the traditional technologies and chemical and biological characteristics of *attiéké* and *garba* abound in Côte d'Ivoire. The country wants to patent them just like the champagne of France.

Our study noted with concern that *attiéké* is produced fresh with a limited storability of about four days. This short lifespan puts severe limitations on outfits selling it and, ultimately, limits the processing capacities of centers to produce what they are sure to sell. It may have also put limits on the research in machinery including steaming. It may be better to add drying to the fresh *attiéké*.

The production flow chart for fresh *attiéké* can be summarized as shown in Plate 9.



Source: Wikimedia Commons



ATTIÉKÉ CYCLE AND PRODUCTION FLOW CHART

Plate 9. Attiéké cycle and processing flowchart.

Dried *garba* and *attiéké* will have a longer shelf life than 4 days and therefore will put fewer constraints on marketing and sales. Processing centers making dried *attiéké* or *garba* will not have to worry about how to sell the product fast at sometimes give-away prices or will not stay idle until they get firm orders before embarking on production as practiced now. They will make their products with ease and have a proper channel of distribution that can span longer distances and times. Dried *garba* and dried *attiéké* can be produced from any place where cassava is available in abundance and sent to areas with high consumption. It can also open opportunities for large-scale production.

Description of the production stages: Tools and machines used

The study took us to two types of processing outfit: a family/neighborhood type (traditional/cottage processing center) and a cooperative type (semi-mechanized one). Both models use the same unit operations in the same succession as shown in Plates 6 to 11. The types of centers differ from one another only in the equipment and types and numbers of some of the tools used.

From our observations and expectations, specific equipment and tools are used for the unit operations. The machine and many of the tools we saw may have been the result of an evolutionary process outside the scope of this study; we will only describe them as we saw them and explain their principle of operation. We will, however, try to explore if there are any signs for further evolution or point out the direction for new research with a focus on the steamer.

Lastly, from our observations, all processing activities are tailored to small-size production. Except for the graters, all tools and machines in use are small; this means the size of production increases only by an increase in the number of (small) machines. It is a significant limitation when trying to create large-scale production.

The following were the stages we found being practiced.

Reception and sorting out

This stage is common to all the products; it is at this stage that the raw material is assessed in terms of quality. We found that this is done on a bare floor in an open place for the neighborhood center and under a shed for the semi-mechanized centers. Most often roots are brought freshly harvested, appropriately cut, so there is not much work in sorting. It is here that operations such as removing rotten roots, wood, excess sand, and stones, if any, are typically carried out. Bare hands and knives are used.

Measuring/weighing

This is the second operation, also common to all products. This stage is meant to evaluate the number of roots supplied but also to share the work among the workers. Data from this stage are used to pay the suppliers (intermediaries, owners, transporters, etc.) even the workers. Buckets and heaps are used in household, cottage, or neighborhood centers; some cooperatives or associations (semi-mechanized centers) also use buckets and heaps to measure the quantities of roots supplied or at hand. Well-established processing centers such as cooperatives, other associations, and most of the semi-mechanized and larger centers use scales (digital or analog) to measure the roots. In Nigeria, the use of weighing bridges is common in processing factories for 50 tons and above, but here, because of the type and size of production, machines of this kind are way out of order.

Peeling

This stage is carried out to remove the outer and inner skins of the roots; these parts are known to contain over 80% of the cyanide, a harmful chemical present in most varieties but especially the bitter ones. Even the sweet type is also peeled before processing. Respondents say that they use hand peeling, and this was corroborated by what we saw on the ground. Everywhere we went, we saw hand peeling practiced with the use of knives of different shapes and sizes. Our research work here in Nigeria has shown that hand peeling is the best method of peel removal, but it is slow, painful, full of drudgery, and especially time-consuming (25 kg/pers/h.) according to Diop (1998).

Brofodume reported that a project gave them a mechanical peeler; we saw the machine there during our visit, but the respondent had a complaint. We were informed that the device is working but it grinds the peel and therefore, they could not find a use for it. The machine was not used at the time of our visit. They explained to us that since that center sells the peel fresh to livestock owners, they prefer to peel manually. Cassava peel never lasts more than 48 hours before spoilage owing to aflatoxins. In Nigeria, IITA and ILRI have come up with an innovative technology and machines that process the peel into livestock feed for chickens, small ruminants, cows, pigs, and fish; these are stable products that can last as long as eight months. Both institutions run training courses for processors and feed millers that can benefit the processors in Côte d'Ivoire.

Over the years, Nestlé, the world's largest food and beverage company has tried and is still trying to develop a peeling machine for their operations in Côte d'Ivoire, but these efforts are still "Work in Progress" as they have not yet come up with a suitable machine for their use. Let us also note that IITA, since 2004, has put a lot of efforts on research for efficient peeling machines by working with fabricators and the academia; so far this research has come up with six different machines of about 1 t/h capacity and a peel removal of above 80%. Unfortunately, IITA and Nestlé, despite a long history of collaboration, have not managed to pool their efforts to work on peeling machines and methods. IITA is trying to publicize their machines and Nestlé could benefit from them.

During our visit to I2T, we saw efforts to develop a mechanical peeling machine based on an existing imported sample prototype, but this is also still at the research level.

The three organizations, Nestlé, IITA, and I2T, are each working separately on mechanizing peeling for now; if they cooperate in this research, all of them stand to benefit. In Germany, there is an excellent peeling machine, but it costs a lot (€40 million or USD1,334,000.00); there are other machines from China, Brazil, and indeed from Thailand too but all of them need to be adapted to the requirements in Africa. Coming up with a small peeling machine could be a breakthrough for the sector in Côte d'Ivoire and Africa. IITA has come up with six different machines and has its large cassava farms, constant electricity, and experience in machine development; it could be an excellent working ground to pool these efforts on mechanizing peeling.

Whether mechanizing peeling would lift cassava processing in Côte d'Ivoire is a big question. Given the size of operations there we think hand peeling will remain the main player unless research comes up with small-size peeling machines.

Cutting

Cutting or chipping the peeled and washed roots is practiced by all processing centers in Côte d'Ivoire. This operation is meant to reduce the peeled roots to small sizes; this operation goes together with peeling and washing, and all are carried out manually using ordinary (kitchen) knives. Respondents claim that cutting the roots into small pieces will facilitate grating, among other benefits. During our study, we did not measure the time it takes, but one can say mechanization could go a long way into hastening this stage of processing.

Cutting is usually followed by washing; roots are immersed in clean water as the cutting goes on; the pieces from the cutting or chipping are thrown inside a bowl containing water. When cutting is completed, the roots are washed and made ready for grating.

In Nigeria, there are various machines (both locally made and imported) to cut cassava roots; some have a capacity of 1 t/h. When it comes to increasing processing capacities in Côte d'Ivoire, machines like those in Nigeria will be convenient. IITA also introduced a manual cutting machine in Cameroon; this machine can also be helpful in Côte d'Ivoire.

Grating

The grating is common to all the six products derived from cassava in Côte d'Ivoire. This operation is meant to reduce the peeled and washed pieces of roots to a pulp that flows like a thick liquid. It is also a mixing operation as it is at this stage that the inoculant accelerating fermentation and the palm oil are injected while the small pieces are being fed into the hopper of the grater. Traditionally, grating used to be done using a perforated metal sheet, bent and fixed over a plank. These traditional tools may still be in use in some parts of Côte d'Ivoire, but we did not witness them; instead, we saw mechanized graters equipped with either 7.5 or 15HP engines. Processing outfits either had graters of that type or took their roots to a service provider for fees ranging from CFA500/bowl to payment in kind.

All the graters we saw are the same. They consist of a frame that supports the whole structure, a hopper, a feeding funnel, a grinding chamber, and a chute. Inside the grating chamber, there is a shaft with beaters and a set of sieves. An electric motor drives the whole shaft. The overall height of the machine is about 1.5 m; the quality of the pulp produced is good, and the machine may well produce 1 t/h or more. This machine is different from the graters in Nigeria, which use perforated drums and may have the edge over them as its shafts and beaters can outlive the drums.

The grater found here costs around CFA2.2 million (roughly USD3,826 or ₦1,377,391; 1USD = ₦363) according to information from processors and the local fabricator.

Fermenting

We were told that the pulp is left to sit in containers such as buckets, for 12 or 24 hours or 2 or 5 days, to ferment; the inoculant mixed during the grating was reported to shorten this period to just 12 hours. Literature suggests that this is the stage at which the harmful chemicals are removed, and the taste and aroma evolve. Respondents just told us that they practice fermentation to have good and safe products.

This process has been fully studied and documented by researchers in Côte d'Ivoire. It is possible to scale up this operation as has been done in Nigeria.

Pressing

Pressing is done using small screw presses of 40 by 40 cm square and about 50 cm high with a screw at the center. All centers have a multitude of these small presses. We counted 12 presses at Yopougon-Ananerais; Brofodume reported that each of its 18 members had a press. This large number of presses points out the kind of production at which they are aiming and how they increase their volume of production (by increasing the number of small machines). In neighborhood processing centers, the presses are put on top of a bowl; small cotton or empty rice bags are filled (1/3) with the mash; and the bags are folded into small balls and between 5 and 7 of them are placed inside a press. The pressing is done by turning the handle of the press. The water expressed is collected inside the bowl, decanted, and the starch scooped out. In semi-mechanized processing centers, which are expected to deal with larger volumes, the presses are put on top of old automobile tires placed on top of gutters; the gutters are interconnected, and the liquids expressed from the pressing are channelled to a place to collect the starch. At Brofodume, they use a centrifugal machine for pressing the mash which they say gives them good results. Small presses cost around CFA25,000 and the centrifugal machine costs CFA2 million (3,478.26 USD or ₦1,262,608.38) (1 USD = ₦363).

Sifting

In Côte d'Ivoire, as we saw it, sifting is crucial, common to all the products and plays two roles: crumbling the cake and sieving. All the sieves seen during our visit were the traditional type; a kind of wooden frame (bamboo type) of 40 by 40 cm with a screen (mesh) in it. The sifter should be placed on top of a bowl; the material to be sieved is put inside the sifter directly on top of the inside screen, and bare hands are used to break the cake and force the materials through the mesh (the screen) of the sifter. The output increases only by increasing the number of sifters.

We did not take data on cake breaking and screening. We did not see mechanical sifters even in the semi-mechanized centers; it is a missing machine.

In Nigeria, we have several mechanical sifters that can process small quantities, but that can also process about 1 t/h. How this machine can help processors in Côte d'Ivoire needs to be explored.

Granulation

Neighborhood centers and the like had hand-carved wooden circular bowls used for granulation; it is an oval type tool 60 by 66 cm wide with a depth of 17 cm. These are held by hand; the pressed and loosened wet mash is poured into it. The tool is held firmly with both hands, shaken, and rotated when the contents are thrown up into the air to get the granules of cassava flour to evolve. How much time is required to make a given amount of mash was not captured as we were mostly there to understand the technology of *attiéké*. Cooperatives and the like have both manual granulators as described above and mechanical granulators. Some cooperatives had two mechanical granulators. Brofodume had two granulators; one was given to them by the project, they found it slow and had to buy a second one themselves; both were being used. At Ananeraie, we saw two granulators. A mechanical granulator costs as much as CFA1.8 million as we were informed.

Drying

Drying or the process of removing the moisture is done for various materials. In *attiéké* production, drying usually follows granulation and is meant to make granules stronger and ease the removal of fibers among others. In Cote d'Ivoire, we found drying applied in both *garba* and *attiéké* production. Starch is also dried. Sun drying is the conventional method. The centers visited had either open spaces or dedicated concrete floors (flat or in a platform); some processing centers had nylon or bamboo mats. Materials to be dried are spread over the surfaces of these devices and left to dry. Cooperatives have elevated concrete floors dedicated to sun drying. At least one center (Brofodume) had in addition to the elevated floor, a solar tent dryer with tables that we found unused because the tent was torn, and erosion of the foundation threatened to bring down the structure.

Winnowing

Winnowing or fanning is used to extract and remove the fibers and other foreign objects from the materials before or after granulation. It is practiced on the dried granules differently according to the center.

Family and neighborhood centers use traditional tools. Any bowl is used; it is filled with the material to be fanned, then the filled container is lifted above head height, and the contents of the bowl or the material to be fanned are sprinkled from that height to a mat or into another bowl. This operation is carried out while falling a wind current. The draught blows away the fibers while the granules fall onto the mat or inside the other bowl placed on the floor; women repeat this for as long as is needed to complete the removal of the fibers. This is done outdoors in the open to catch and make use of the wind.

Cooperative centers used the same method, but an electric standing fan could replace the wind current; the fan is used indoors. Certainly, dust and other things can contaminate the materials being fanned by this method.

We could not see what mechanized outfits use for winnowing, but it is possible to make simple machines, motorized or manual, that can carry out this process at various capacities, even in *attiéké* and *garba* production.

Grading

Grading is the process of sorting out the granules according to selected sizes. We found it practiced in various stages of the production process. It is part of the manual granulation whereby the pellets that have reached the required dimensions are removed from the granulation pan, and the others are broken manually to continue the process. It is also used as a quality enhancing operation during *attiéké* production when granules before steaming are graded, and the same sizes are kept together for steaming.

Manual tools are used as those for granulation.

Steaming

Steaming is a method of cooking using steam. Water put inside a container is brought to the boil to evaporate; the vapor so formed is made to cross a mass of materials and thereby cook it. Generally, steaming is an excellent cooking technique that can be used for many kinds of food. In *attiéké* and *garba* production, the materials to be cooked are the granules obtained from the granulation or grading operation. The equipment used is called a steamer; these are essential devices. They are common in the processing centers where all were found having traditional steamers, which are devices capable of processing around 20 kg of product/batch for 35 minutes at a time.

There have been attempts to introduce improved steamers, but we were told that these did not meet expectations. That is why processors resorted to the traditional ones. The cottage center at Akardio was found using only one steamer, but they said they had another at the Chairperson's house. At Ananeraie, we saw eight spots for (traditional) steamers that appeared to be continually used. At Brofodume, one traditional steamer was found in use, and this center had two other different "improved steamers" that they got from projects. However, both were unused as they neither met the expectations of the group. The reasons given to us are discussed later.

All the centers were found using the same type of traditional steamer as those newly introduced did not give them satisfaction. They had complaints about each of the new ones. A traditional steamer is made of three parts:

1. a heating chamber
2. a water pot
3. a perforated container serving as the real steamer.

The cost of one new type of steamer was given as CFA1.2million, but that is one which was put aside awaiting collection by its fabricator.

Production process of *Attiéké*

Table 7. Production process for *attiéké*.

	Names of processing centers visited		
	Brofodume	Akradio	Ananeraie
Describe your production process	Put granules into the steamer. Stir 4 times for <i>attiéké</i> normal, once for <i>agbojama</i> , twice for <i>garba</i>	Peel - cut (manual), grate (mechanical), ferment 12 h, press (screw press), granulate, dry (sun), fan, steam	Not captured (N/C)
Cooking time	35 min	Not captured (NC)	N/C
The best source of heat	Wood is good. Gas could be best, but it is costly	Wood	N/C
Optimum capacity for steamer	Not estimated	Not measured	N/C
Additional information	None	We need an off-taker for our product	N/C

Source: Fieldwork 2018.

We tried to capture if there was any difference in the production process from one center to another using questionnaires and group discussions. It appeared that respondents have the same flow chart and use the same traditional steamers. They listed them as **PEEL/CUT** (manual), **GRATE** (mechanical; all grating was mechanical either using their graters or a service provider), **FERMENT** for 12 h, **PRESS** (screw press), **GRANULATE**, **DRY** (sun drying was the norm), **FAN** (sprinkling the material from pans across a natural draught was the norm). The natural wind flow was enhanced using an electric fan), **STEAM** (using traditional steamers).

In the cooking time, we captured 35 min for a batch in one of the centers, and we assumed that this should be the same for all others since they use the same steamers. It was observed that there was a need for stirring and returning the materials during cooking and the content was not loaded all at once. Numbers of stirs differed from normal *attiéké* (4 times) to *garba* (twice), and *agbojama* (once only).

The best source of heat was identified as gas, followed by wood; gas was reported to be too expensive, that is why all of them said they preferred using wood. A load of wood brought by a motorbike equipped with a trailer that can produce 1000 boules or the equivalent of 1 and half months' operation at Akradio, cost CFA10,000: CFA5,000 for a load of wood and CFA5,000 for transport. At times, some centers that have gas-fired equipment use wood. When they get a request from a contractor to use gas, they do not refuse but ask that contractor to bring bottles of gas which they use for that order.

Optimal capacity was not captured, but earlier respondents informed us that a batch for them is 20 kg; this one could be the optimal one. The semi-mechanized centers found our questionnaire complete and did not find anything to add; the cottage type begged for off-takers to take their products.

Quality of *attiéké*

Table 8. Types and qualities of *attiéké*.

	Names of processing centers visited		
	Brofodume	Akradio	Ananeraie
Which type of <i>attiéké</i> is the best?	All of them are good	<i>Attiéké</i> normal is the best	Not captured (N/C)
What criteria makes it best?	It depends upon individual taste	Quality of inoculant, quality of the oil, and the presence or lack of fibers	N/C
Variations in steamers for <i>attiéké</i>	All steamers are the same	There is no variation for all kinds of <i>attiéké</i>	N/C
Best capacity [kg]	20	20	N/C
Materials used	Aluminum and stainless steel	Aluminum	N/C

Source: Fieldwork, 2018.

From the questionnaires and the discussions, we found that there could be varied opinions on which *attiéké* is the best and what makes it the best. For some, the normal *attiéké* is the best; for others, all are the same, but it depends upon the individual. The presence of fibers and oil or the lack of them are the main criteria. According to Djeni et al. (2008), the type and quality of the inoculant can affect the quality of *attiéké*.

Respondents did not see variations in the steamers. All are using the same traditional steamers. One thing to note is the fact that all introduced “improved” steamers have been put aside, and processors have returned to use the old traditional steamers and this was of interest to us. The optimal capacity has been reported to be 20 kg. The material used was mostly aluminium for the water pots and stainless steel or aluminium for the steaming chambers.

The price of one of the steamers was given to us by a fabricator as CFA1.2 million corresponding to one of the “improved steamers” that are yet to be accepted. The cooking temperature was reported to be 100 °C.

Marketing of *attiéké*

Table 9. Marketing of *attiéké* as practised by the processing centers.

	Names of processing centers visited		
	Brofodume	Akradio	Ananeraie
Your buyers	Everybody: diaspora, Ivorians	Our sisters in Abidjan	Not captured (N/C)
Having own list of buyers	Yes	Yes	N/C
Selling other products	Yes	No	N/C
Which ones?	Cassava peel	N/A	N/C
Main products made by this center	<i>attiéké</i>	<i>attiéké</i>	N/C

Processing centers have challenges in selling their products, especially those located far from urban centers because the product (*attiéké*) is perishable and spoils within four days. Processors respond to this challenge by usually, not doing any processing if they do not have firm orders. The buyers include neighbors, local citizens, relations in towns, a network of retailers, and the diaspora. The Neighborhood centers, usually with a small processing capacity, sell only *attiéké* fresh and wet, which places constraints on marketing.

Fully mechanized processing centers are contemplating production of dried *attiéké*; how successful they are was not captured during this study, but it is an excellent way to ease out the marketing constraints faced by these processors. Semi-mechanized centers with bigger processing capacity sell the peel from the roots in addition to their *attiéké*. The cottage centers visited informed us that they do not have any income from the peel because they give this out to livestock owners; it may not be the case for all similar centers.

Fabrication of improved steamer

The fabrication of an improved steamer was the core assignment of this study. We visited the processing centers with the purpose of (1) seeing all the types of steamers being used, (2) studying the components of each these steamers and the way they operate.

The following are our findings.

Types of steamer being used in Côte d'Ivoire

- All processing centers use only traditional steamers.
- There have been attempts to introduce other types, but all the steamers so added did not meet expectations, so were dropped and processors, big and small, returned to using the traditional steamers.
- All traditional steamers we saw in use have the same components; they have almost the same dimensions and capacity; they can be gas-fired, but all of them were found using wood.
- The steamers are all operated in the same way.

Components of traditional steamers

Each steamer is made of three main components: A heating chamber, a water pot, and a steaming chamber (Plate 10).



Plate 10. Components of the traditional steamer.

Source: 2018 Field trip

Heating Chamber. The heating chamber is usually made of clay built in a circle of 50 to 60 cm with a height of about 28 to 35 cm; the one we measured at Akradio was 28 cm high and 61 cm in diameter. An iron framework often supports the clay walls. It has an opening for the wood to be put in and that is the kind of fixed cooking arrangement often seen in the cottage and communal processing centers. Semi-mechanized processing enterprises have adopted similar heating chambers with the same dimensions but with metallic frames and walls; these can be moved around unlike the fixed clay types.

Water pot: Unlike the heating chambers that can be clay or metal, the water pot is the same for all steamers. It is an open pot of 20 to 35 liters capacity, similar to the kitchen pots used to boil yam, rice, etc. The most popular are made with cast aluminium. The water for steaming is added to this pot, and it placed on top of the heating chamber. The diameter of the pot is about 40 cm and the height about 30 cm as we measured it at Akradio.

The cooking or steaming chamber: The cooking chamber is the component in which the steaming takes place. It is an open aluminium bowl, round in shape, 22 cm high. The bottom is either pierced with numerous holes or left open to let the steam to pass through, but then the hole is covered by a perforated metallic plate and by a porous nylon or cloth material. The quantity and movement of the steam inside the cooking chamber are critical for good steaming.

The steamer described above is the only design in use. All the others did not work for various reasons.

Description of some of the new steamers introduced

There is no study on the introduction of steamers. Our findings are the outcome only of the interviews we conducted with processors during this mission which are summarized here.

Three types were introduced over the years by different projects: (1) gas-fired. (2) gas-fired multiple bay, and (3) rectangular or channel type, with the following outcomes.

Gas-fired steamers

Gas-fired steamers were the first to be introduced. The ordinary gas burners were fitted inside the burning chambers under the water pots. The burning chambers must have been changed from clay materials to metallic walls. But the processors we met did say that using the gas for *attiéké* production is expensive; they did not give further reasons and no study has captured any others.

Using gas for cooking generally is not common in remote towns and villages because of the difficulties in finding gas and the lack of knowledge on how to use it. Therefore, the use of gas in such locations is prohibitive, also affecting the production of *attiéké*. It could be one of the reasons why gas-fired steamers were rejected there.

In urban areas, all sources of heat are used. Therefore, the use of gas for steaming should be an option. But if processors are still complaining of the high cost of the gas for *attiéké* production, it could be that the introduced burners are not efficient, the metallic chambers are ill-adapted, or that the cost of other sources of heat (wood, charcoal) is lower than the cost of gas. It could also be that the price at which the *attiéké* is sold cannot cover the use of gas. Plate 11 below shows the types of burners coming with the gas-fired steamers found during our field trip, but these were not used.



Plate 11. Gas-fired burners for steamers set aside. *Source 2018 Field trip*

Gas-fired multi-bay steamers

This type has multiple water pots placed together on the same metallic frame. They were meant to increase the production of *attiéke*. We saw two, and three bays all mounted on the same frame. These types could not be used for reasons of cost. It could be the high cost of gas or reduced utilization of the generated heat. This information was not captured since the steamers we saw had long been set aside (Plate 12) .

As said, inefficient cooking could not be captured but placing two (or three cooking spots as we saw in Brofodume) side by side on a high metallic frame, very close to each other, could be one of the causes that made them difficult to operate; this adds to the general problems of the use of gas-fired steamers as discussed above (9.3.1).



Plate 12. The three-bay *attiéké* steamer at Brofodume. *Source: 2018 Field trip*

Gas-fired rectangular steamer

The Gas-fired rectangular steamer is the latest introduction. It is a rectangular box with two chambers placed on top of one another (Plate 13). The gas burners to provide the heat are placed underneath the bottom chamber. We did not see a study on that type of steamer, but a few them were being manufactured by one of the fabricators. We also saw over 10 of the same type in a warehouse awaiting distribution. At Brofodume, we saw one such machine the processors had acquired using their own money in an attempt to increase production. They tried to use it without success, saying that it produced wet *attiéké* that they could not sell. They have since called the fabricator to come to collect his steamer and return their money. It will be better to subject this steamer to more testing first.



General view of the rectangular steamer



Components of the rectangular steamer

Plate 13. View and components of the rectangular steamer. *Source: Field trip, 2019.*

In any case, there is room for more studies on this matter for the sake of increasing science, preserving the environment, and finding other ways to produce *attiéké* more efficiently. For now, gas-fired steamers were ranked by cooperatives as the best and wood-fired as the second-best, but they added that gas was expensive. They would use gas for producing *attiéké* only if the contractor supplied the gas and the processor would charge only for labor.

Conclusion

The project to design and construct a steamer for *attiéké* that was assigned to IITA in response to the growing need to improve the production of *attiéké* in Côte d'Ivoire was carried out between June and December 2018. Desk research and an extensive literature search were made and complemented by a beneficial trip to Abidjan. The trip helped the multidisciplinary team, put in place by IITA and CIAT, to obtain vital information from local processors active in *attiéke* production, covering mainly the various unit operations involved with an emphasis on the steaming process. The main findings can be summarized as follows:

- Cassava, the third most important food crop after yam and rice, is consumed in Côte d'Ivoire in various forms: fresh roots, *cossettes*, *placali*, starch, tapioca, *garba*, and *attiéké* with *attiéké* being predominant and gaining ground in West Africa, Europe, and the Americas.
- Information on the processing techniques of the products mentioned above was studied.
- A lot of research work has gone on with *attiéké* processing and quality improvement but little on the steam cooking method for this essential food item.
- The study found that all processing centers use traditional steamers despite numerous efforts by government agencies and NGOs to introduce new kinds of steamers to improve, sanitize, and notably increase the production of *attiéké*.
 - i. Three types of steamers have been introduced over the years by different projects: (1) gas-fired, (2) gas-fired multi-bay, and (3) the rectangular or channel type; all have failed to find acceptance.
 - ii. The team tried to find out from the processors the reason(s) for not accepting the introduced steamers. The main reason is that the new steamers are producing poor quality *attiéké* that consumers could not accept.
 - iii. Studies have been planned to design, construct, and evaluate a steamer that will be cheaper and produce *attiéké* of acceptable quality. The team will try as much as possible not to repeat the mistakes of those previously introduced.

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