

# State of Knowledge on Fresh Yam & Pounded Yam in Côte d'Ivoire

Understanding the Drivers of Trait Preferences and the Development of Multi-user RTB Product Profiles, WP1

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# ABSTRACT

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The objective of this state of knowledge was to gather key findings on pounded yam from the literature and key informants and deduced the gap of information in order to better set the objectives of the upcoming research on pounded yam in Côte d'Ivoire.

Quality characteristics of raw yam are mature tubers, free of wounds, with a high dry matter and attractive flesh, which does not turn brown at peeling. Medium size yam tubers with a regular shape facilitating peeling are more appealing to consumers.

Varieties of yam affected the quality and acceptability of pounded yam. Yam tubers with less water, mostly *D. cayenensis-rotundata* give better pounded yam than those lodged with water (*D. alata*). Storage of yam tubers also improves the quality of pounded yam, as it increases tubers dry matter.

Most important quality attributes of pounded yam are color and textural properties (cohesive, stretchable, smooth, moderately soft and less sticky). Pounded yam without black spots is also preferred. The textural properties depend a lot on the physico-chemical composition of yam tuber such as starch content and composition, starch properties, protein and mineral content, secondary metabolites (polyphenols, etc.).

The processing steps of pounded yam is the same across cultures and countries. The main difference lies in the pounding, the time, and the addition of water and/or other roots to obtain a more stretchable dough.

In Cote d'Ivoire, the consumption of pounded yam depends more on ethnic group. Baoules, Abrons, and Koulangos, located in the centre and the north-east of the country consume more than other groups. Their average consumption can reach 73 kg of yam/person/year, against 22 Kg of yam/person/year.

**Keywords:** Yam, state of knowledge, pounded yam, quality, texture, yam consumption

# 1 MODULE 1: FOOD SCIENCE

## 1.1 Methodology

### 1.1.1 Sampling and data collection method

In this first phase of the preliminary study, information collected was obtained from interviews with key informants. The latter were selected because of their proven experience in yam and pounded yam. They are mainly researchers, officers of the Ministry of Agriculture, actors of the value chain of yam. Each key informant was interviewed on the three domains, and they were asked to answer to the best of their knowledge. Most of the data was collected face-to-face, and some key informants preferred to reply to questions by email.

Scientific articles and reports of studies related to yam and related products were also consulted.

Research questions that this food science module aims to address are:

1. What are the characteristics of the raw material that will give a good quality product noting differences between processing methods, regions, ethnicity etc.?
2. What are the key steps in processing and preparation that will give a good quality product noting differences between processing methods, regions, ethnicity etc.?
3. What are the known quality characteristics of the raw material associated with each stage of processing and preparation, to the final product?
4. What are the known quality characteristics of the final product?

### 1.1.2 Data Analysis

Data, essentially qualitative, were analyzed by comparing the information obtained from key informants with that contained in the various articles and reports consulted. This information then synthesized to provide answers to the different research questions.

#### Document Quote Journals

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## 1.2 Narrative summary

### Description of the raw material characteristics that will give a good product.

Yams (*Dioscorea*) are annual climbing plants cultivated in tropical regions of the world (Soro et al., 2010). Their characteristics, which can result in a good quality pounded yam (*foutou*), have been the subject of numerous studies. These characteristics are found in the skin, flesh, maturity, shape, varieties, and physicochemical composition of the yam.

#### Yam skin and flesh

A yam tuber capable of producing a good quality pounded yam must be free of external damage. The skin of this yam must be healthy; it should not have insect bites and wounds (Barlagne et al., 2017).

Important characteristics of the flesh of a yam tuber that can give a good *foutou* are the color and texture of the skin (Trèche, 1997). According to this author, the color of the flesh results from the presence of pigments, mainly carotenoids and glucosides, the most frequent of which are anthocyanins. For Doumbia (2014), yam that can make a good quality *foutou* must have a flesh free of black spots.

#### Yam maturity

Yam capable of giving a good *foutou* must be mature (Wireko-Manu et al., 2013). The maturity of the tuber influences the quality of its food product, especially for pounded yam. In the traditional environment, farmers judged the maturity of yam tubers by the drought of the vines (Okoli, 1980). Indeed, yam tubers harvested during the drying of the vines have more economic value for farmers and processors due to high content of dry matter and starch (Wireko-Manu et al., 2017). Abass et al. (2003) adds that better quality food, especially *foutou*, are obtained from tubers harvested during the drying of the vines. Wireko-Manu et al. (2017) stated that the maturity or time of harvest of *D. alata* has a significant impact on their physicochemical and texture (stickiness) characteristics.



## Yam shape

For Trèche (1997), the quality of raw yam is assessed by the shape of its tuber. He pointed out that the appearance of the tuber is one of the important characteristics of a yam that can produce a quality *foutou*. Indeed, this author indicates that for *foutou*, consumers prefer tubers that are not too big and that have a shape that allows easy peeling. Barlagne et al. (2017) specify that yam tuber should be medium in size and regular in shape that facilitates peeling. Likewise, Amegbeto et al. (2008) reported that in Togo, consumers prefer small, lightweight, and conical yam tubers.

## Variety

For Kouassi (2009) and Prof Georges Amani, the quality of yam *foutou* depends on the variety of yam used. Varieties of *Dioscorea rotundata-cayenensis* are the most suitable for pounded yam. Unlike *D. alata*, *D. rotundata-cayenensis* has a high filling power, low capacity for amyloidosis and water binding. In fact, its *foutou* is cohesive, stretchable, moderately soft and less sticky compared to the *foutou* made using *D. alata*. *Foutou* from this latter is very soft, non-stretchable, sticky and non-cohesive (Otegbayo et al., 2011).

In the Côte d'Ivoire, among the varieties of the species *D. rotundata-cayenensis*, kponan and wacrou are the most popular for making pounded yam. In addition, their *foutou*, satiates quickly and longer and does not break between fingers. Of these two varieties, kponan is preferred because of its sweet flavor which is adapted to the Ivorian taste (Kouassi, 2009).

According to Prof Georges Amani and Nindjin et al., 2007, varieties of the species *D. alata* are less preferred for making yam *foutou* due to the high-water content of their flesh). For this purpose, they do not give a quality pounded yam (Wireko-Manu et al, 2017).

However, with the storage, some varieties of these *D. alata* species manage to give a quality *foutou* at certain times of the year (lean period for early varieties). These are the *florido* and *bete-bete* varieties. Of these two varieties, *florido* is more popular in the preparation of *foutou* because of its taste and consistency when stored for a long time (Kouassi, 2009). The author pointed out that *foutou* from *bê-tê-bê-tê* has a rather poor image for consumers because it is tasteless and soft.

## Physico-chemical properties

One of the characteristics of the quality assessment of yam *foutou* is its protein content (Babalola et al., (2016). For the authors, the protein content of yam is a criterion for assessing the sensory characteristics of *foutou*. It promotes the extensibility or elasticity of the dough and thus contributes to making the *foutou* dough more malleable or more tender. Generally, the protein content of yam varies between 1.7 and 10.9%, and even more of the dry weight depending on the variety. This content is influenced by the variety, cultivation practices, climate, growing season and yam production area (Woolfe, 1987). The protein content of the yam produced in Côte d'Ivoire varies depending on the variety and the production area (Kouassi, 2009, Ebah et al, 2019). In Bondoukou, the oulégni variety contains 16.56% protein while in Bongouanou and Abengourou, sopiè variety contains 10.52% and 10.36% of protein, respectively.

In addition to protein, other physicochemical components of yam such as starch also determine the quality of *foutou* yam said Prof Georges Amani and Otegbayo et al., (2011). For Amani et al. (2004), starch makes up about 60-80% of the dry matter of the yam tuber. This author emphasizes that starch is a dominant factor in determining the physicochemical, rheological, and textural characteristics of food products of different species of yams. According to Otegbayo et al. (2011), it influences the bulking power, the gelatinization temperature, and the viscosity of pounded yam. Indeed, the size and shape of the starch granules of yams can influence the swelling and viscosity of pounded yam (Lindeboom et al., 2004; Otegbayo et al., 2011). The large starch granules allow faster swelling of yam (Sanguanpong et al., 2004). To this end, Prof Georges Amani and Otegbayo et al., (2011) stated that the varieties of *D. rotundata* have a high bulking power, a low water binding capacity and a high content of phosphorus because they contain more large starch granules than *D. alata*. In fact, the *D. rotundata* varieties give a tender and stretchable *foutou*. Rasper and Coursey

(1967) showed that the consistency and elasticity of the dough of *D. cayenensis-rotundata foutou* is related to the relatively high viscosity of its starch and its moderately strong gel.

**Summarize the quality characteristics of the raw material at each step of processing and preparation to the final product, identified in the key informant interviews and authors using in text citations.**

The way of preparing and consuming food is specific to each culture and people. Yam *foutou* is a dough of varying texture obtained from yam cooked in water, pounded to an acceptable thickness, and rolled into bread (Firca, 2010). The main stages of processing and preparation, whether traditional or modern, do not generally differ between countries and ethnic groups (Kouassi, 2009). The differences appear at the final stage of crushing, according to the preferences of consumers about the characteristics of the dough (soft or hard dough, stretchable, etc).

### ***Key stages of processing and traditional preparation of pounded yam***

The main stages in the preparation of pounded yam described by Prof Georges Amani are:

#### **Peeling and cutting of the tubers**

For a good quality *foutou*, the size of the pieces is important and depends on the water content of the tubers. Yam tubers with low moisture content like *D. rotundata-cayenensis* species or tubers that have been stored for longer period, must be cut into small pieces to have well-cooked and soft pieces in less times. The flesh should not turn brown (oxidation).

#### **Washing of the pieces**

Yam pieces colored by the high presence of secondary metabolites like polyphenols (browning) are washed longer to remove the maximum of brown spots on them. This browning is more common with species of *D. alata* (*bêté bêté* for instance). The washing is necessary to avoid off-flavor in the final product.

#### **Boiling in water (the cooking time will depend on the size of the pieces and the yam variety used)**

Yam pieces must be cooked until softened but should not absorb too much water. As explained in question (1), the characteristics of starch in the variety used play significant role in the absorption of water.

#### **Draining of the excess of water**

#### **Pounding (until a smooth paste is obtained)**

The pounding process is also one of the key steps in the preparation of quality *foutou*. The cooked pieces are crushed in a mortar with a pestle until a glutinous, consistent paste is obtained. The differences in the pounded yam process are mostly found at this stage. The method of pounding and the time depends on the variety and the ethnic groups.

According to FAO (2003a), yam pieces must be crushed hot. Ethnic group like Agni and Abron from east of Côte d'Ivoire like the dough to be more stretchable, like a "chewing gum". So, water is added, and/or roots like cassava or taro are added. And the pounding is done longer. Other ethnic groups like Baoule, prefer soft and minimally stretched dough.

For Nindjin et al. (2007), to obtain a quality *foutou* (solid and pasty) with *D. alata*, it is necessary to let the pieces cool down after cooking for a certain time before crushing them. On the other hand, yams of *D. cayenensis-rotundata* species must be crushed while hot.

## Summarize the quality characteristics of the final product identified in the key informant interviews and authors using in text citations.

Yam *foutou* is a dough of variable texture that is smooth (Attaie et al, 1997). According to Otegbayo et al. (2006), the textural attributes of a quality pounded yam are stretchability, cohesion (moldability), hardness, firmness, smoothness, and a reasonable degree of tack (tackiness). For Egesi et al. (2003), the acceptability of a yam *foutou*, by consumers, is judged by its sensory qualities. These qualities are thickness, color, gloss, smoothness, tackiness, elasticity, and hardness. To this end, these authors stated that a quality *foutou* must be creamy white, very shiny, smooth, non-sticky, hard, cohesive, consistent, and elastic. However, thickness, color, and stickiness are the most defining attributes of consumer preference. For Burton, (1989), the thickness of the ground yam is the key indicator of the quality of this dish. According to FAO (2003 b), yam *foutou* is of good quality if it is tender (elastic) and without lumps.

In Cote d'Ivoire, good quality yam *foutou* is attractive by sight, touch and taste (Doggnimeto et al., 2010). In the same vein, Nindjin et al. (2007) pointed out that Ivorian consumers judge the quality of pounded yam by the color and the appearance. For these consumers, yam *foutou* should be smooth and shiny like the surface of a tomato. It should not be fibrous, lumpy, loose, sticky, watery, and should not be stained.

Moreover, *foutou* made with *D. rotundata* is more appreciated by consumers than that of *D. alata*. In fact, the pounded yam from *D. rotundata* is stretchable, cohesive, hard (firm, not rigid), smooth, slightly tacky, and sweet. On the other hand, that of *D. alata* is lumpy, very soft, loose, very adhesive, not moldable and hard (Otegbayo et al., 2011).

A study by Nindjin et al. (2007) shown that Ivorian consumers prefer flrido *foutou* over Bê-tê-Bê-tê because of the high-water content of the latter variety. For Kouakou et al. (2012), consumers appreciate C18 over flrido because of its culinary qualities.

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## 2 MODULE 2: YAM DEMAND IN CÔTE D'IVOIRE

### 2.1 Objective

The aim of the Demand SoK (State of Knowledge report) is to understand the demand for the product, drawing on Segmenting-Targeting-Positioning (STP) Framework. The objectives are to identify different demand segments for the product, define who and where the demand for the product is, and the characteristics associated with preferences for the product. Importantly, a demand segment includes consumers who pay money for the product and those who may grow the crop and prepare the product at home for family consumption.

### 2.2 Methodology

#### Data collection

In this first phase of the preliminary study, information was collected from scientific articles and reports of studies related to yam and related product.

The research questions for the demand module are:

1. What is the demand and trends in demand for the product, from people who pay for the product and make and consume it themselves?
  - a. What are the different demand segments associated with the product?
  - b. What is the size of the different demand segments and what are the trends for the product?
  - c. What are the geographical and demographic characteristics of the demand segments for the product?
2. How do the demand segments correspond to preferred characteristics for the product?
3. How the product is transported, stored and sold, and by who (e.g. gender, socio-economic status, age, region etc.)?

#### Data Analysis

Data, essentially qualitative, were analyzed by comparing the information obtained from key informants with that contained in the various articles and reports consulted. This information then synthesized to provide answers to the different research questions.

#### Journals

| 1.1 Citation                                                                                                                                                                                                                                                               | 1.2 Country and region of focus |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------|
| <b>Amegbeto N. K., Manyong, Coulibaly, Asiedu V. M., O, R., 2009</b> , «Determinants of market value for fresh yam ( <i>Dioscorea species</i> ) tubers in two consumption centers in Togo» <i>In Annales des sciences agronomiques du Benin</i> , N°9, Volume 2, pp 29-47. | Togo                            |
| <b>Bakayoko G. A., Kouamé K. F., Boraud N.K. M., 2017</b> , « Culture de l'igname au centre-est de la Côte d'Ivoire : contraintes, caractéristiques sociodémographiques et agronomiques » <i>In Journal of Bioscience</i> , N° 110, pp 10701-10713.                        | Côte d'Ivoire, M'Bahiakro       |
| <b>Ceylor/Padyp, 2012</b> , <i>Module production végétale</i> , fiche 2 : la culture de l'igname, CNRA (Bouaké), 6 p.                                                                                                                                                      | Côte d'Ivoire, Bouaké           |
| <b>Chaleard J-L., 1986</b> , «Croissance urbaine et dynamisme rural: l'igname des lobi (Côte d'Ivoire) » <i>In Nourrir les villes en Afrique subsaharienne</i> , Paris, pp 130-147.                                                                                        | Côte d'Ivoire, Bouna            |



| 1.1 Citation                                                                                                                                                                                                                                                                                                                                                | 1.2 Country and region of focus           |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------|
| <b>Cornet D., 2005</b> , <i>Systèmes de cultures associées à base d'igname et gestion des plantes adventices</i> , Travaux d'étude approfondie préalable au doctorat (Sciences Agronomiques), Gembloux, 30 p.                                                                                                                                               | Benin                                     |
| <b>Girardin, O. 1996</b> , <i>Technologie après-récolte de l'igname : étude de l'amélioration du stockage traditionnel en Côte d'Ivoire</i> . Thèse, École Polytechnique Fédérale Zurich, Suisse, n° 11710, 298 p.                                                                                                                                          | Côte d'Ivoire                             |
| <b>Koffi K.G. J. C., 2015</b> . <i>L'igname chez les Agni-bini de Côte d'Ivoire : dynamique culturelle et changements de pratiques alimentaires</i> , Thèse de doctorat (sociologie de l'alimentation et de la consommation), Université Felix Houphouët-Boigny de Cocody, Abidjan, Institut d'Ethnosociologie, 309 p.                                      | Côte d'Ivoire, Kouassi-Datékré, Boahia    |
| <b>Kouakou P. K., Kouassi C. A. Anoh, K. P., 2019</b> . «Le Marche Gros De L'igname Kponan A. Abidjan (Côte d'Ivoire)», <i>In European Scientific Journal</i> , Vol.15, N° 26, pp 218-237.                                                                                                                                                                  | Côte d'Ivoire, Abidjan                    |
| <b>Kouassi N. F., 2009</b> , <i>L'igname chez les baoulés de Côte d'Ivoire : Essai d'une socio-anthropologie de l'alimentation</i> , Thèse de Doctorat (sociologie et anthropologie), Université de Bouaké, Bouaké, 594 p.                                                                                                                                  | Côte d'Ivoire, centre de la Côte d'Ivoire |
| <b>Mahyao G. A., 2008</b> , <i>Etude de l'efficacité du système d'approvisionnement et de distribution des ignames précoces Kponan à travers le circuit Bouna-Bondoukou-Abidjan en Côte d'Ivoire</i> , Doctorat thèse unique, Université de Cocody-Abidjan, Côte d'Ivoire, 219 p.                                                                           | Côte d'Ivoire, Bouna, Bondoukou, Abidjan  |
| <b>Mahyao G. A., Dombia S., Zohouri G. P., Zoungrana P., 2009</b> , «Rentabilité des investissements dans le commerce de gros des ignames en milieu urbain : cas des grossistes d'Abidjan en Côte d'Ivoire » <i>In Annales des sciences agronomiques du Bénin</i> , N°9, volume 2, pp 69-92                                                                 | Côte d'Ivoire, Abidjan                    |
| <b>N'Egesi C., Robert A., James K-E., Mpoko B., 2003</b> , « Genetic diversity of organoleptic properties in water yam ( <i>Dioscorea alata</i> L) » <i>In Journal of the Science of Food and Agriculture</i> , N° 83, pp 858-865.                                                                                                                          | Nigéria, Ibadan                           |
| <b>Nama M. G., 2005</b> , «Potentiels nutritionnel et technologique des tubercules durcis de l'igname <i>Dioscorea dumetorum</i> (kunth) pax : Étude du durcissement post-récolte et des conditions de transformation des tubercules durcis en farine », Thèse de doctorat (Science alimentaire et nutrition), Université de Ngaoundere, Ngaoundere, 255 p. | Cameroun, Ngaoundere                      |
| <b>Ngue-Bissa. T., Mbairanodji A., Njualement D., 2007</b> , <i>Guide des techniques de Production et de Conservation d'ignames (Dioscorea spp)</i> , PNDRT, Cameroun, 30 p.                                                                                                                                                                                | Cameroun                                  |
| <b>Nindjin C., Konan G., Agbo N., Otokore D., Bricas N., Farah Z., Girardin O., 2009</b> . «Les variétés d'igname ( <i>Dioscorea spp.</i> ) rencontrées sur les marchés en Côte d'Ivoire et leur préférence culinaire» <i>In Annales des sciences agronomiques du Bénin</i> , N°9, Volume 2, 12 p.                                                          | Côte d'Ivoire                             |
| <b>Nindjin C., Otokore D., Hauser S., Tschannen A., Farah Z., Girardin O., 2007</b> , « Determination of relevant sensory properties of pounded yams ( <i>Dioscorea spp.</i> ) using a locally based descriptive analysis methodology » <i>In ELSEVIER</i> , N°18, pp.450-459.                                                                              | Côte d'Ivoire                             |
| <b>Sawadogo A., 1977</b> , <i>L'agriculture en Côte d'Ivoire</i> , Paris, France, PUF, 367 p.                                                                                                                                                                                                                                                               | Côte d'Ivoire                             |
| <b>Stessens J., Nindjin C., Daouda D., Girardin O., 1998</b> , <i>Amélioration du stockage de l'igname au Nord et au Centre-Sud de la Côte d'Ivoire</i> , Document de travail N° 13, Projet 'Renforcement des études agro-économiques à l'IDESSA', IDESSA-K.U. Leuven, 48 p.                                                                                | Côte d'Ivoire, Dickodougou, Toumodi       |
| <b>Wireko-Manu I., Oduro A. E., Asiedu R., Maziya-Dixon B., 2017</b> , «Changements de qualité alimentaire dans l'igname d'eau ( <i>Dioscorea alata</i> ) Pendant Croissance et stockage », <i>In Journal asiatique des sciences de l'agriculture et de l'alimentation</i> , N 3 Vol1, pp 66-72.                                                            | Ghana, Kumasi                             |

## 2.3 Narrative summary

### What is the demand and trends in demand for the product, from people who pay for the product and make and consume it themselves?

Yams play a role as a diversification product in the evolution of the food system in urban areas of sub-Saharan Africa (Bricas and Sauvinet, 1990; Bricas, 1993). For the urban population not originally from yam production areas, the consumption of yam is considered a treat, as is the case in Cotonou, Lomé and Abidjan (Bricas et al., 1998).

In Côte d'Ivoire, in term of selling, Abidjan receives the largest quantity of yams intended for selling, before Bouaké and other cities. However, data show that the consumption of yam in rural or urban areas depends first on the culture, so on ethnical groups than the place of residence and the socio-professional class.

Akan and Burkinabe consume more yams than other people in urban areas. They are followed by the Mande-North and the Mande-South. Surveys showed that the Burkinabe and Akans have respectively a consumption higher than 73 and 52 kg of yam/ person / year, whereas the Mande-North and Mande-South consume respectively only 22 and 17 kg / person / year (Requier-Desjardins, 1990).

In the cities of the centre, area of production and consumption of yam (Bouaké, Yamoussoukro, Dimbokro, Didiévi and M'Bahiakro), the ethnic group of consumers is decisive in the consumption of yams, the indigenous Baoules, who represent 50% of the population), give priority to yams over other foods. 75% prefer **pounded yam**, followed by *boiled yam*.

Baoules consume more yams than Agni or Adioukrous (from Dabou) for whom the yam is increasingly becoming an occasional food, consumed during festivities (EBC, 1979). Rich people in urban areas consumed more yams than others in the same urban areas.

The consumption of yam also depends on its accessibility, and on the income of the family. In rural areas where it is produced, yam is consumed more than in urban areas; moreover, data indicates that families with an income of less than 100,000 FCFA/month consume less yam than those with greater incomes (Consumption Budget Study (E.B.C) 1983).

### How do the demand segments correspond to preferred characteristics for the product?

Yam is a staple food for people in both rural and urban areas. Its purchase in urban areas is guided by the cost, the availability and preference or not for imported foods that are more accessible due to the diversification and change in dietary habits.

In Côte d'Ivoire, as previously said, preference for yam and pounded yam depends on culture, meaning geographical origin, and socio-professional status.

Pounded yam ranks as sixth preferred food product for the Ivorian population but ranks at the 4<sup>th</sup> position for men (Kouassi, 2009).

Population from the Center, East and North-East eat more pounded yam than others. However, the characteristics of the product differ according to ethnic group. Baoules, even though yam symbolizes a remedy for hunger and more, they like the sweet taste and soft texture of pounded yam, as well as moderate elasticity (Kouassi, 2009). Abron people like elastic and very soft pounded yam; for this reason, they add some water during the process of pounding. Baoules

Age is another factor influencing the demand for pounded yam. Baoules living in the cities, despite the diversity of dishes and the time constraints imposed by the urban lifestyle. Many "traditionalists" between 40 and 70 years continue to consume yam. This age group prefers to consume it as pounded yam, at home at lunchtime or in restaurants. As for the young, most find pounded yam too heavy to digest and often difficult to prepare; therefore, they opt for fries, boiled, accompanied by sauces ... made from meat products (Kouassi, 2009).

## How the product is transported, stored and sold, and by who (e.g. gender, socio-economic status, age, region etc.)?

### ***Transport of post-harvest yam***

Yam tubers are generally transported and marketed in bulk inside the producing countries or during transborder exchanges. This mode of packing causes wounds on the tubers, and post-harvest losses

After harvest, yams are transported from the place of production to the place of marketing via the consolidation points (Mahyao, 2008; Kouakou et al., 2019). The means used to transport these tubers depend on the stakeholders involved in the sale. In the production areas, the wholesalers' collectors, who are men, use 20 tonne vehicles to transport the yams in bulk (Ebah et al, 2019) from the fields to the place of storage. If the production is small, yams are transported with bicycles, motorcycles, tricycles, even on the head by the producers. From the storage location, the wholesalers' collectors or producers (mainly men) transport the yams to the wholesale markets in the big cities (Abidjan, Bouaké, etc.) using 20 tonne vehicles. In urban centers, yams are transported to retail markets in taxis, tricycles, and rickshaws (Mahyao, 2008). The transport of yams in the cities is negotiated according to the distance to be traveled (Kouakou et al., 2019). Taking the example of the city of Abidjan, these authors let us know that when the wholesalers are in the same municipality as the retailer, transport varies between 250 and 500 FCFA per 100 kg of yam. Otherwise, retailers rent vehicles, and the rental price of which varies from 5,000 f in Abobo and 800 fcfa in Adjamé (Mahyao, 2008).

### ***Storage of yam after harvest***

African consumers have a strong preference for fresh yam tubers. However, these tubers cannot be stored for long in the ground beyond their maturity stage. They must be harvested in a relatively short period and stored to extend their period of availability on the markets, but also to make more benefit (Ngue-Bissa et al., 2007). The author emphasizes that before storage it is important to observe certain rules which are fundamental for the prevention of damage due to rotting and weight loss. He said that before storage, the tubers should be dry cleaned in order to remove pieces of soil, injured parts should be cut off the with a sharp knife. There are two types of yam storage: traditional storage and non-traditional storage (Nama, 2005).

#### ***Traditional storage***

There are several types of traditional yam storage

##### *The conservation of the yam in the mounds*

This method of preservation allows the yam tubers to be left in the mounds despite their maturity until the time of sale or consumption (Nama, 2005; Kouassi, 2009). This storage time lasts between one and four months depending on the variety (Kouassi, 2009; Celcor / Padyp, 2012). While this process makes it possible to limit weight loss depending on physiological and physical factors, it presents significant risks of attack by insects, nematodes and rodents. The occurrence of floods causes tubers to rot (Nama, 2005; Celcor / Padyp, 2012).

##### *Storage in pits or silos*

Here, pits located in the field and lined with straw are used for storage. Tubers are arranged either horizontally or vertically. Those pits offer protection against weight loss related to breathing and sweating, but rots are favored by the lack of ventilation and direct contact between the tubers (Ngue-Bissa et al., 2007; Celcor / Padyp, 2012). To reduce this damage, Ezeike (1985) cited by Nama (2005) suggests storing tubers in well-ventilated pits. (Ngue-Bissa et al. (2007) and Celcor / Padyp (2012) indicate that the conservation of yams in pits does not promote regular control. In fact, the farmer cannot detect damage in time in order to fight against it.

### *The piles on the ground*

After harvesting, the yams are stored in heaps on the ground or on a layer of straw or liana carpet installed under a tree and covered with straw. This system does not require additional costs and provides some protection against heat; however, it is poorly ventilated and does not allow the necessary control (Ngue-Bissa et al., 2007; Celcor / Padyp, 2012). Yams rot easily afterwards. (Ngue-Bissa et al., 2007). For Celcor / Padyp (2012), contact with the soil favors the attack of the parasites and the contamination from one tuber to another.

### *Conservation under straw roof shelters*

Yam tubers are placed in a heap inside a conical-shaped shelter, built with maize or sorghum stalks and placed in the shade of a tree. The investment for this shelter is minimal. Aeration is better than in the case of the heap placed on the ground, which reduces the damage (Ngue-Bissa et al., 2007). If this shelter is well built, it can retain crops for three consecutive years (Celcor / Padyp, 2012). However, it is open to the intrusion of insects and rodents. The quality of yamscanonly be controlled there (Ngue-Bissa et al., 2007).

### *The clay granaries*

This attic is built in the form of a hut with hard walls and covered with a straw roof. It is mainly found in savannah areas. Tubers packed inside are protected from rain and sun. Clay and straw used as building materials create a favorable temperature. However, aeration between the piled tubers is insufficient and their inspection difficult. Yams later rot easily (Ngue-Bissa et al., 2007). In Côte d'Ivoire, this method of conservation is more practiced in the northern regions of the country (Stessens et al., 1998).

### *Vertical braids or hurdles*

It is a system with wooden piles separated from each other. These timbers are stabilized by horizontal posts. Tubers are tied up to each other on vertical stakes using ropes (Stessens et al., 1998; Ngue-Bissa et al., 2007). To avoid too much exposure to sunshine, the frame of the racks is oriented in the East-West direction and the tubers are always covered with palm leaves (Stessens et al., 1998). The vertical braid is the most popular storage system in West Africa (Ngue-Bissa et al., 2007). In Côte d'Ivoire, vertical braids are used in the central regions of the country (Stessens et al., 1998). The racks allow perfect ventilation. Tuber control and removal operations are easy. This storage system is a lot of work because each tuber is tied separately. However, yams are not protected against insects and rodents. During the rainy season, the tubers receive a lot of moisture and rot easily (Ngue-Bissa et al., 2007).

Furthermore, Ngue-Bissa et al, (2007) report that there is no traditional yam storage system that offers sufficient protection against rots and pests, and facilitates regular inspection at the same time, aiming to detect damage early in order to take measures to reduce it. The success of yam storage depends on the initial state of tubers (physiological age at harvest, wounds, infestation by insects and microorganisms, onset of rotting), (Coursey, 1967, cited Nama, 2005 ).

## ***Non-traditional storage or improved storage***

### *Curing*

It is a method which consists in exposing the tubers, for a relatively short period of time, to high temperature and humidity just after harvest to promote healing of wounds caused by the harvest and prevent the development of subsequent rots (Girardin, 1995 Nama, 2005; Ngue-Bissa et al., 2007). Ngue-Bissa et al. (2007) emphasize that this technique is only effective against small tuber wounds and lasts between three to fifteen days, depending on temperature conditions (between 25 and 40 ° C) and relative humidity (between 70 and 95 %).

### Use of sprout inhibitors

Sprout inhibitors prevent yams from germinating during post-harvest storage, which extends the shelf life of tubers. Gibberellic acid (GA3 form) is the most effective and used product for anti-sprouting of yams (Nama, 2005). The effect of this product was confirmed in Côte d'Ivoire by Girardin (1996). Results of this author work have shown that the extension of the duration of dormancy induced by gibberellic acid is accompanied by a reduction in deterioration caused by rots and a decrease in water loss in healthy tubers. Along the same lines, Stessens et al. (1998) point out that the use of the GA3 technique has enabled yam producers in central and northern Côte d'Ivoire to store their tubers for a long time and to have substantial income.

### Pesticide treatment

This technique involves soaking the yam tubers as soon as they are harvested in solutions of pyrethroids-based pesticides to reduce the rate of infestation and losses due to insects (Sauphanor and Ratnadass, 1985 cited by Nama, 2005). It enabled yam producers in Toumodi and Dikodougou (Côte d'Ivoire) to store their production Stessens et al. (1998).

### Manual sprout removal

Manual sprout removal involves the manual and regular removal of sprouts from yam tubers. This technique significantly reduces weight loss during storage (Girardin, 1995). Tuber weight losses commonly reach 25% of its initial weight after five months of storage (Osagie, 1992; cited by Nama) and thus reduce the market value of this speculation. This constitutes a shortfall for the producer. In the Ivory Coast, in the regions of Toumodi and Dikogougou, the application of manual germination has enabled farmers to keep their yams for a long time, in good condition and to sell them when the demand is high, for more financial benefit (Stessens et al., 1998). Moreover, this storage technique also improves the seed value of the tuber (Nwankiti, 1988 cited by Nama, 2005).

### Irradiation and lowering of temperature

Artificial lowering of the temperature, irradiation, or even a combination of the two techniques, is effective in prolonging the duration of dormancy and reducing weight loss of yams (Osagie, 1992 cited by Nama, 2005).

### Storage of yams in warehouses or stores

In production areas, yams are stored in warehouses or stores in villages before being transported to urban markets (Mayao, 2008). These stores are either huts built with clay, cement or as high huts (Ngue-Bissa et al., 2007). Storage activities are carried out by the farmer's wives or by other village women who are paid between 5 and 10F CFA for each carried yam tuber (Mayao, 2008).

In large cities like Abidjan, retailers (mostly women) cheap in to rent a small store where they store their yams. In loading/unloading markets, yams are stored on the ground and covered with stores. In Bouaké, yams are stored in the wholesale market stores by wholesalers before their redistribution (Mayao, 2008).

## **The marketing of yams**

### Yam marketing players

From farm-gate sales to retail markets, yam distribution highlights a multitude of players (Kouakou et al., 2019). The main players in the yam sector in Côte d'Ivoire are producers, transporters, collectors or direct sellers, wholesalers and retailers (Mahyao, 2008; Kouakou et al., 2019).

### The producers

Producers are the first link in the chain and are spread across the country (Mahyao, 2008). For the sale of their yam production, farmers contact, either directly wholesale traders based in Abidjan, or sale representatives (Doumbia et al., 2006; Kouakou et al., 2019). They can sell the yams at the gate



of the farm or carry the production to the wholesalers in Abidjan. When they make the trip, they expect to receive a higher profit in return than at the farm gate. In the region of Bouna and Bondoukou, the peasants who produce and sell early yams are from the Lobi ethnic group of Ivorian origin (Chaleard, 1986; Mahyao, 2008). These producers are between 28 and 60 years old. Overall, 81.8% of the producers surveyed are out of school and 18.2% have secondary education (Mahyao, 2008).

### Direct sellers or collectors

Rural collectors assemble products in production areas. Each collector maintains a network of producers that he tries to maintain (Mahyao, 2008). For this author, there are two types of collectors in yam production areas: independent collectors and dependent collectors. Independent collectors are free to work with any wholesaler, while the dependent direct seller is an employee working for a wholesaler; he prospects and purchases yam. He receives from the latter, a commission (2 to 5 F CFA / Kg).

Collectors are generally from the production area and have a better knowledge of the available stocks. In addition to collectors in rural areas, there are direct sellers / distributors or “cozers” in town centers (Kouakou et al., 2019). According to these authors, the latter occupy an important and strategic place in the kponan yam marketing circuit in the cities, precisely in Abidjan. For these authors, they are most often at the origin of the price fluctuations of yam tubers observed on the market. Indeed, direct sellers / distributors provide a sort of bridge between production areas and wholesalers. The cost for the yams transportation (from the source region to Abidjan) is their responsibility. These salesmen are young Lobi or Koulango from the Bouna or Bondoukou region. They have the trust of the wholesale collectors, those in Abidjan and the producers (Mahyao, 2008).

### Carriers

They transport the yams from the production area to the market. They provide a link between the different layers of the market (Mahyao, 2008). They are drivers or owners of the cars or trucks that transport the yams from the production area to Abidjan, and even within the city of Abidjan. The rental price of these trucks depends on the state of the road, the distance and the quantity of yams to be transported (Kouakou et al., 2019). Authors point out that this cost is sometimes calculated per kilogram of the journey traveled and obeys two scenarios. When the yam is pre-collected and stored in town or in the regional capital, the transport costs from this storage location to Abidjan vary between 20 and 25 FCFA / kg. In the case where the truck loads the yam from the field, the rate applied is between 30 and 35 FCFA / kg (Kouakou et al., 2019).

### Wholesalers

The wholesalers ensure central collection, distribution, spatial and temporal integration of the market. There are two types of wholesalers: wholesale collectors (buy yams directly with producers or through rural collectors) and wholesale distributors (sell yams to large towns). Some play sometimes both roles, while commission agents supervise the bargain between wholesale markets, especially for non-resident wholesalers (Mahyao, 2008). According to the results of this author's study, 63.6% of wholesale collectors are Lobi from the production areas. Dioula traders represent 18.2%, Koulango 9.1% and Dega 9.1%). The age of wholesale collectors ranges from 23 to 58 years old and the average age is 35 years old. Almost half (49.4%) of these actors are educated (45.5%).

In the cities, especially in Abidjan, the distribution of early yams is ensured by two types of wholesalers: primary wholesalers and secondary wholesalers. The primary wholesalers in Abidjan receive the yams from Bouna-Bondoukou through the cozers and resell them to secondary wholesalers or retailers. Primary wholesalers are mainly made up of men (96%) and more than half (53%) are under 40 years old. They are dominated by foreigners (57%) including 25% Malians, 23% Nigeriens, 7% Burkinabé and 2% Beninese (Mahyao, 2008). Unlike primary wholesalers, the activity of the secondary wholesalers in Abidjan consists of reselling the yams to retailers or directly to consumers. Secondary wholesalers are exclusively men (99%) and (87%) are under 40 years old. The majority of these traders are Ivorians (71%°



### Retailers

Retailers represent the last million in the marketing system and are mainly women (77%) through several types of channels. Their age varies between 18 and 57 years (Mahyao, 2008). According to the author, the retail sale of yams is dominated by Ivorians (77%). At the level of retailers in Abidjan, two types of activities have been identified: collection-resale and purchase-resale. Malians (8%), Nigerians (8%), Beninese (3%), Burkinabés (3%) and Togolese (1%) are less represented in this activity. The majority of these actors (72%) are out of school. Moreover, according to the same source, the retail sale of yams can be summed up in two activities: collection-resale and purchase-resale. The collection-resale activity consists of the collection of yams in rural markets in production areas for retail sale in urban markets. At Bouna bus station in Treichville, it is men detail collectors who manage, while in Abobo, they are women retail collectors. As for buy-sell, it consists of the purchase of yams by retailers from wholesalers for retail sale in neighborhood markets (Mahyao, 2008).

### Yam distribution channels

According to Kouassi (2009), the distribution of yams in Côte d'Ivoire follows four circuits. The direct circuit (1): in this circuit, the producer sells his production directly to local consumers in village markets; then, the integrated circuit (2): it comprises a marketing intermediary (retailers or collectors) between the producer and the consumer. In the short circuit (3), we generally meet two to three players: wholesalers, commission agents, retailers) between the producer and the consumer and finally in the long circuit (4), the number of intermediaries is high (on average three at four)).

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