

State of Knowledge on Fried Plantain in Nigeria

Food Science, Gender & Market

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Ethics: The activities, which led to the production of this manual, were assessed and approved by the CIRAD Ethics Committee (H2020 ethics self-assessment procedure). When relevant, samples were prepared according to good hygiene and manufacturing practices. When external participants were involved in an activity, they were priorly informed about the objective of the activity and explained that their participation was entirely voluntary, that they could stop the interview at any point and that their responses would be anonymous and securely stored by the research team for research purposes. Written consent (signature) was systematically sought from sensory panelists and from consumers participating in activities.

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ABSTRACT

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The SoK report was developed based on a review of existing literature on plantain from Nigeria and other countries where plantain is a predominant crop and interviews with key informants in Nigeria. The report addresses aspects of production, marketing and consumption of plantain. Although the focus is fried plantain (dodo), the report also focuses on other plantain products since little is known about the relative importance of dodo and plantain products within Nigeria in general. The SoK also considered the role of bred plantain hybrids (improved plantain varieties) disseminated in Nigeria which is also a focus of the end user survey.

1. INTRODUCTION

This report is part of the RTBfoods project, Work Package (WP) 1. The main objective of RTBfoods is to inform RTB breeding programs in order for these to develop and select varieties that meet user-preferred quality traits, aiming to increase the adoption and impact of improved RTB varieties in sub-Saharan Africa. The core task of the RTB foods project is therefore to define the key user-preferred quality characteristics in relation to the food products made from RTB crops. This work is covered by WP1 through subsequently: surveys, participatory processing and consumer testing with end-users to develop product profiles for different user segments. However, before designing and conducting the survey part, a state of knowledge report is developed which will provide an overview of the existing knowledge on user preferences and how they differ for different user groups. This report is the state of knowledge report for plantain products in Nigeria with a central focus on fried plantain, which in Nigeria is widely known as *dodo*.

This report summarizes the scoping study which combines a review of literature from Nigeria and other countries where plantain is a predominant crop, with key informant interviews in Nigeria. Key informant interviews were conducted in the South West and South South of Nigeria, two important plantain producing areas and focus areas for the end-user survey in Nigeria. The scoping study addresses three areas; production, marketing and consumption of plantain. Key informants were selected based on their knowledge and expertise on these components of the plantain value chain. Although the focus in the context of the project is fried plantain (*dodo*), the study also explores other plantain products since little is known about the relative importance of *dodo* and plantain products within Nigeria in general. Another specific focus of this review is to ascertain the role of bred plantain hybrids (improved plantain varieties) disseminated in Nigeria.

2. PLANTAIN PRODUCTION

Nigeria is one of the largest plantain producing countries in the world (Akinyemi, 2010). Plantain is mostly produced in Nigeria's South West, South South and South East, which include Cross River, Akwa-Ibom, Imo, Enugu, Rivers, Edo, Delta, Lagos, Ogun, Osun and Oyo states. These areas are covered by forest soils and have an annual rainfall of more than 1000 mm per year during a period of 7 to 9 months. The main harvest of plantain is during the dry season from November to February (surplus period), although fruits can be harvested year-round.

Plantain cultivation requires relatively low labour inputs compared to other staple foods and is therefore attractive to farmers. Plantain is mostly produced by small-scale farmers who integrate plantain production into various cropping/production systems. Plantain is commonly intercropped with cocoa in the South West and Cross River state, the cocoa producing areas of Nigeria. Plantain can also be intercropped with crops like cassava, egusi melon, cocoyam and yam. This production system is most common in the humid rainforest area of the country. Another production system (Taungya farming system) is that where plantains are intercropped with trees destined for timber production (Ayanwale, 2016). In this production system, the plantain provides a source of income before the trees are mature and can be logged. This is commonly practiced in Ogun, Ondo and Edo states, and accounts for around 10% of the total plantain production. Plantains are also found growing on various points around the compound. This system can mostly be found in the South East of Nigeria, and accounts for 15 to 25% of the total plantain production. The last production system of plantain is in plantation form, destined for commercial production under monoculture. Although this production system is becoming more popular, management has been poor due to lack of technical know-how (Akinyemi, 2010).

Key informants explain that although plantain was popularly used as shade crop for cocoa production, plantain is now mostly planted around people's homestead or in plantations (key informant interview with Philip Oladeji, Adeniji Basiru, Olalekan Jeremiah, 15 May 2019, Ibadan). Some farmers may intercrop plantain with other crops like watermelon, pepper and yam. Plantain production starts with the sourcing of suckers. Although most farmers source suckers from their own farm, a certain percentage (around 30% according to key informants) may be sourced off farm. This

happens mostly when farmers establish a new plantain farm, where the old plants suffered drought, or where pests and diseases are prevalent. Suckers are bought for between 50 – 250N, with prices being highest in the South South, especially around Port Harcourt.

A large-scale farmer in Delta North indicated that he uses a special instrument for uprooting the suckers to prevent the breaking of roots as is the case when using a spade (key informant interview with Robert Okrakpor, 31 May 2019, Asaba). Ideally, farmers remove a sucker from any stand that has three or more stems. Suckers need to be cleaned by treating them with insecticide and fungicide after uprooting them. After treatment, the suckers need to be left in the shade for at least 24 hours before planting. If clean suckers are used, farmers can harvest 3 to 4 times from one plantain instead of only once (key informant interview with dr. Akinyemi, 7 May 2019, Ibadan). One key informant explained that cutting off the leaves of suckers promotes faster root development (key informant interview with Robert Okrakpor, 31 May 2019, Asaba).

Rotation of plots where plantain is planted (not planting plantain on the same plot each subsequent year) is a good agronomic practice to prevent pests and diseases such as weevils. It is advised to plant suckers in rows (key informant interview with Akinyemi, 7 May 2019, Ibadan). By the time one plantain stand is harvested three times, a sucker can be replanted in the center of the rows. Planting is done at 2 – 3 by 3 meters spacing. Some key informants indicated that the holes that are used for planting need to be big, so that the soil will be soft for root development, while others were sticking to 30x30cm hole size. Most key informants recommended to apply organic fertilizer such as chicken manure. Generally, fertilizer needs to be applied two to three months after planting, and before weeding. For weeds not to affect the plantain, it is important to weed every six to eight weeks. Besides, it is advisable to plant banana and plantain in separate fields to easily detect diseases. The chairman of the Plantain Association of Oyo explained that it is easier to detect diseases on plantain than on banana because diseases will turn the plantain leaf into a pale colour (key informant interview with Philip Oladeji, 15 May 2019, Ibadan). The easiest way to control diseases is to remove the plant and burry or burn it. Women may be more attentive and in some cases detect diseases in an earlier stage, while only the owner of the farm can decide to remove stands, which are usually husbands of the women. This means a woman can indicate to her husband that she suspects a disease and advise him to remove infected plants. Key informants from the Plantain Association in Oyo explained that, unless the woman has ownership over the plantain plantation, she cannot destroy an infected or diseased plantain plant (key informant interview with Philip Oladeji, Adeniji Basiru, Olalekan Jeremiah, 15 May 2019, Ibadan).

Plantains start fruiting 7 to 8 months after planting, although this is dependent on the location and the rainfall in that area. In the South South, all key informants explained that plantain can be harvested within a year, sometimes even within 10 months after planting. In Nigeria's South West, farmers only harvest bunches after 1.5 years. Between November to February (the dry season) there is much plantain in the market (surplus period), while by the end of February till August (the dry season) plantain becomes more difficult to find (scarce period). Farmers who have plantain during that period can sell their bunches for a higher price. Plantain is harvested upon maturity, 90 days after flowering. If plantains need to be transported over larger distances (for example from Asaba to Abuja), marketers may demand farmers to harvest within 80-86 days after flowering, to increase storability/shelf life.

2.1. Gender dimensions of plantain production, processing and marketing

According to the key informant interviews conducted both in the South West and South South, ownership of land is tied to the male head of a household in Nigeria (similar across regions). This means in some families, men and women cultivate the same land together while in other households men may dedicate a separate field for their wives.

As for most staple foods, men are mostly involved in the production of plantain, while women are more engaged in the processing and marketing aspects. Men carry out land preparation for planting of the suckers, farm maintenance and management and harvesting of the plantain bunches when

matured. At the same time, it is assumed that family labour is an important input to plantain farming. Men also play a larger decision-making role than their wives in most, but not all aspects of cultivation, such as where to plant suckers, procurement of suckers, pest/disease control, staking, removal of stumps, and transplanting of suckers. In terms of cultivation, women play a larger role in decision-making regarding manure application, recognition of mature fruits, removal of dry leaves that are close to the ground and fire tracing (Ajayi, 1998).

With regards to plantain production, men in the South West are more involved in the different steps between planting to harvesting, while in the South South, women are traditionally more responsible for the entire production process. Key informants explain that a woman can handle all steps from planting till harvesting in the South South and South East, which is not the case in the South West. In the South West women only do farm work that is not too tedious. In the South South and South East there are relatively more women in plantain production. Key informants attribute this to a cultural difference between the regions in Nigeria. While men in the South West do not want to stress their wives too much (key informant with dr. Akinyemi, 7 May 2019, Ibadan), men in the South South make the land available and leave it to the women to cultivate. Key informants also explain that in the South South specifically, men prefer to spend their days drinking and leave their women to do most of the work (key informant interview with Dr Tanimola and Kamalu Onywyechi, 30 May 2019, Port Harcourt). The head of the ADP¹ in Asaba was keen on further emphasising that after the payment of the bride price, men in the South South consider their wife as labour asset: a woman will have to work to make up for the price her husband paid (key informant interview with Ben Agamah, 31 May 2019, Asaba).

Although production of plantain can be handled almost entirely by women in the South South and South East, most key informants in the South West explained that in the South West men handle the more tedious work related to plantain farming. For example, after land clearing (which is a man's task), men will dig the soil and cut the suckers, after which it is the duty of the women to carry the suckers to the permanent place for planting. In the South West, the application of fertiliser and chemicals is mostly done by men, although especially the application of fertiliser can be done by women as well. Weeding is done by both, although by some seen as predominantly a men's task and by some seen as mostly a women's task. Harvesting can be done by both as well. Most key informants in the South West explain that while men will harvest the bunches, women will carry the bunches from the field to the homestead or selling place. Sales of plantain is generally a women's task, both in the South East, South South and South West. Women will follow the car or bike that is transporting the plantain from their farm to where they will sell the plantain. Many of the wholesalers and retailers on the markets in the South West and South South are women. Decision-making power over different aspects of cultivation and marketing is in the first place defined by ownership of the land, generally male members of the household. However, if specific plots are allocated to female members of the household, through the process of planting, they gain the control over the management of the planted crops.

These traditional practices are seen to shift with the increase in commercial farmers, where anyone (man or woman) with enough money can invest in land and the set-up of a plantain farm or processing factory (key informant interview with Hon. Eleto, 30 May 2019, Port Harcourt). Commercial farmers are still seen to be predominantly men, presumably because they have better access to financial means. On commercial farms, mostly labourers are engaged. Labourers are generally men although one large-scale commercial farmer in Asaba explained to specifically work with women for certain tasks, such as trimming of the leaves (key informant interview with Robert Okrakpor, 31 May 2019, Asaba).

Women play a more dominant role in processing and value addition in plantain. On a small-scale plantain is mostly transformed into plantain chips, *boli* (roasted plantain), *dodo* (fried plantain), *dodo-ikire* (spiced and fried overripe plantain), or dried plantain flakes. Women often run small-scale

¹ ADP stands for Agricultural Development Project. ADPs were established in 1975 as three enclave projects in Funtau, Gombe, and Gusau. Presently, ADPs have evolved into state-wide project which covers the whole states of the country (Omonona, 2009). The main objectives of the projects are to promote agricultural and rural development especially among the small-scale farmers. The term ADP therefore has become a synonym for the government's rural extension service.

enterprises that process chips, *boli* (mostly in roadside restaurants/*buka*'s), *dodo*, *dodo-lkire* or dried plantain and that require limited investment. Several key informants highlighted this as a very lucrative activity. One even mentioned people having constructed houses with the money earned through *boli* processing (key informant interview with Kingsley Amadi, 30 May 2019, Port Harcourt). Plantain is often sourced from their own farm, neighbouring farms or from neighbourhood markets (Adewole, 2017). At the same time, there is a small percentage (5%) of men that is involved in processing of plantain on commercial scale (Bill and Melinda Gates Foundation, 2015).

In terms of marketing, women across the Southern belt of Nigeria play a dominant role as wholesalers, retailers, and traders, and women often informally organize the market and set the price of fresh plantain bunches. *"In many locations female market supervisors, often known locally as "market queens," manage every market and regulate the quantity and price, and often, new entrants are not permitted to sell their produce if they do not belong to that market"* (Dzomeku, 2011). This practice limits the options of smallholder farmers to selling their plantain at farmgate, which reduces their bargaining power and puts them at a disadvantage.

Ineffective post-harvest handling of plantain forms a major source of loss to the rural and urban women who are mostly engaged in the marketing of plantains. Women are mostly occupied with the ripening of plantain, linked to the quick marketing and reselling of the fruits. Women play a dominant role in the purchasing of the unripe bunches, the removal of plantain fingers from bunches, washing, preparation of ripening containers and checking of the fruits/stage of ripening. At the same time, it is often husbands that provide the initial capital for women to start a plantain marketing business (Ajayi, 2017).

Although negotiable through labour investment, ownership over resources and income from plantain production is often linked to ownership of the plantain trees and land. Across the South West and South South, women who bring plantain bunches to the market generally pay their husband the amount they have made per bunch. The selling price is defined by the husband in advance, or he trusts that his wife brings back whatever money she was able to get for the plantain bunches. However, many key informants explained that some women may declare only part of the real price to their husband and keep a small profit for themselves. In case a woman processes plantain, she may buy the bunches from her husband after which she can keep the profit she makes.

2.2. Improved varieties

As a reaction to the threat posed by Black Sigatoka disease, IITA developed and released several improved, disease resistant varieties in the year 2000 (Faturoti, 2010). These hybrids were distributed to smallholder farmers in 11 states of southern Nigeria: Abia, Akwa Ibom, Bayelsa, Cross River, Delta, Edo, Imo, Ogun, Ondo, Oyo and Rivers. The hybrids were disseminated through public and private extension bodies, together with the dissemination of improved agronomic practices (Faturoti 2009). Before official release of several hybrids, IITA implemented different on farm trials in the before mentioned states between 2001 and 2003 to check the performance of hybrids in farmer managed fields and identify farmers' preferences. For these trials, bunch weight, crop cycling index (frequency of harvest) and resistance to black leaf streak were considered most important traits for genotype performance. Due to differences in variables as rainfall and temperature affecting performance, the hybrids performed differently in each state (Lemchi, 2011). Apart from these differences, it is suggested that adoption is influenced by farmers' socio-cultural values regarding the culinary uses and processing potential of the varieties. For example, people in Southwestern Nigeria prefer foods with low sugar content. The socio-cultural values and culinary uses seem more determinant in the farmers' preference for a variety than the agronomic performance of the crop. For example, in the Niger Delta, PITA 14 that has very similar bunch features to those of Obino L'Ewai, a traditionally grown landrace, was rated excellent (Tenkouano, 2010).

Although socio-cultural and culinary values are very important for the adoption of new varieties, other factors influencing adoption by farmers in the plantain growing belt of Nigeria are high yield, fast cycling and good post-harvest qualities. Also, resistance to Black Sigatoka disease, compatibility with the local plantain cropping system, and the potential for cash income are important determinants in the preference and adoption of a variety (Tenkouano, 2010). Based on these factors, an on-farm

evaluation of Musa Hybrids in Southern Nigeria shows that across the banana growing belt of Nigeria, PITA 14 and PITA 17 ranked highest. Besides the similarity of PITA 14 to a locally grown landrace, they were also appreciated by farmers for their high yielding capacities, fast cycling and good post-harvest qualities. PITA 14 also demonstrated resistance to Black Sigatoka disease, compatibility with the local plantain cropping system, high yield and cash income (Tenkouano, 2010).

The factors influencing adoption relate to both consumer preferences and agronomic practices. In an agro-economic evaluation of Agbagba and PITA 14, the agronomic factors considered included the number of days from planting to flowering, bunch weight, number of hands, number of fingers, and finger weight, among others. Cooking preferences include fruit size and texture, maturity period, resistance to diseases and pests as well as cooking time. The study also considered economic performance, such as food and income generating abilities (related to yield, harvest and frequency of harvest). The results of the study show that PITA 14 has a high Black Sigatoka resistance, a reduced cropping cycle, high average bunch weight and more bunches compared to the local Agbagba variety. These attributes all point to higher cash income from PITA 14 compared to Agbagba (Lemchi, 2005).

An agronomic and sensory evaluation of hybrids in Ghana revealed that the hybrids were appreciated for their tolerance to Black Sigatoka disease. Also, in terms of agronomic characters, 94% of the farmers found that hybrids are superior to landraces. In addition, hybrids remained green throughout the year providing shade for young cocoa plants. Apart from agronomic qualities, food and processing qualities were also evaluated. FHIA 21 (plantain hybrid) was ranked best in terms of yield, taste and commercial potential by 63.9% of the respondents. BITA-3 (cooking banana hybrid) was rated second on its processing qualities. PITA hybrids were evaluated as tasty and good when boiled in slices for *fufu* by 65% of the farmers, although some indicated that the hybrids were more watery than landraces when cooked (Dzomeku, 2007). In Ghana, *fufu* is often made by pounding cassava and plantain together.

Another study in Ghana shows that there are no significant differences between boiled green sliced plantain of FHIA 21 and Apem (local French plantain) in terms of taste, texture, flavour and colour. At the same time, the hybrid was valued for its agronomic practices and resistance to Black Sigatoka disease (Dzomeku, 2008).

A study on cultivar preferences and consumption patterns in the Urban Area of Abidjan show that there are 4 cultivars available on the market. *Ameletiha* is the most preferred cultivar, followed by *Agnrin*, *Afoto* and *Kpatregnou* respectively. The study shows that the different cultivars are mostly preferred for their respective cooking qualities, while the physical parameters such as the shape of the fingers, the size of fingers and the aspect of plantain fingers are not important in consumer's choice (Kouamé, 2013).

During the key informant interviews, it was noticed that improved varieties are more widespread in the South South than in the South West. In the South South, the Delta Agricultural and Rural Development Programme (DARDA) estimated that 10 to 20% of farmers in Delta are growing improved plantain hybrids, less than the estimated people growing banana hybrids (key informant interview with James Onobreawaye, 29 May 2019, Agbarha). In Agbarha, Delta South, farmer Adjarho received different varieties from IITA (plantain: PITA 14, cooking banana: BITA 3, sweet banana: FHIA 23 and 25). He explained that PITA 14 did well, and that it was the only hybrid that the local people accepted. Acceptance of PITA 14 is high because it looks more like the local plantain variety. He explained '*we have a local variety that produces many fruits like PITA 14, and its pulp is similar to the PITA 14 too*' (key informant interview with Adjarho, 29 May 2019, Agbarha). PITA 14 was said to be suitable for making food products like *dodo* and boiled plantain. The main reason for disadoption of the other hybrid varieties can be explained through their morphological appearance. Hybrids that were not accepted by the market produced short fingers looking more like banana than plantain (key informant interview with Adjarho, 29 May 2019, Agbarha). This is similar to statements of the ADP colleagues in Port Harcourt, who received PITA 14 and 17 from IITA, which were not accepted because they were like banana instead of plantain in terms of morphology of the fruit. Although the taste of these varieties was accepted, the fruits were short and therefore not preferred (key informant interview with Kingsley Amadi, 30 May 2019, Port Harcourt). Another reason is related to the quality of the fruit itself. Adjarho explained '*there is one PITA variety that produced bunches*

of almost 30kg, but people didn't like it because when you boil it the pulp is soft' (key informant interview with Adjarho, 29 May 2019, Agbarha). The ADP office in Port Harcourt mentioned three reasons for a cooking banana cultivar (named Cadaba) that came from IITA in the early 90s to go extinct. Firstly, people did not like it because of its taste, which was not sweet. Secondly, the cooking banana ripened quickly so it was difficult to keep. And thirdly, agronomically it expands quickly and dominates other varieties (key informant interview with Kingsley Amadi, 30 May 2019, Port Harcourt). Professor Tanimola from UniPort explains *'the people in the local areas prefer their own local variety. When I asked them why, they said that the market price (of Cadaba) is not high like the local plantain varieties. That is probably because the look is different. They also said that the peel is thicker than that of the local variety'* (key informant interview with Professor Tanimola, 30 May 2019, Port Harcourt).

Apart from food and agronomic preferences, unawareness plays a role in the limited adoption of improved varieties. Professor Tanimola from UniPort explains *'people are afraid to adopt a new variety, they are afraid to lose their traditional planting material and they are afraid that the new variety is not steady. Farmers in Nigeria like to stick to what their grandfathers used to do'* (key informant interview with Professor Tanimola, 30 May 2019, Port Harcourt). Farmers (mostly large-scale) who turned to improved varieties generally did so because they were experiencing problems with pests and diseases on the traditional plantain varieties. One of the key informants, a commercial farmer in Rivers East, explains *'initially I grew a locally sourced variety. But they were not doing well, because they were attacked by diseases. That is why I decided to go to IITA, where I got the variety that I planted last year March. It is disease resistant. The taste and all other aspects of my improved plantain are acceptable for the market'* (key informant interview with Francis Eleto, 30 May 2019, Port Harcourt). The farmer could however not tell the name of the variety so it is not sure if this variety is a hybrid or not as IITA has also been providing non-hybrid varieties.

Through these farmers, who are generally also sellers of suckers, the hybrid varieties get distributed to more farmers. Some of these clients of suckers specifically ask for hybrids, although they are not always aware of the different hybrid varieties and their characteristics. Apart from high yield and disease resistance, main reasons for cultivating improved varieties is early maturity and dwarf stands. In that regard, main reasons for cultivating improved varieties seems to be related to the agronomic characteristics rather than the fruit itself.

3. PLANTAIN MARKETING

Plantain is largely sold by the smallholder farmers who produce it. Only 7% of plantain production is eaten on farm, while 93% (in total accounting for 2.1 million MT) is sold by farmers. 75% of the total production goes to the fresh market, and only 18% of the total plantain production is used for processing (mostly into chips and flour). High market prices contribute to low on farm consumption. Plantains are mostly sold to local, regional and urban markets. 68% of plantain (of which 5% processed) goes to urban consumers, while 30% (of which 10% processed) is consumed by rural customers (Bill and Melinda Gates Foundation, 2015). A large part of the urban demand comes from Lagos, where 50% of the total national production is consumed. There are three main markets for plantain in Lagos: Ikorodu, Owode and Mile 12. On these markets, plantains from different plantain producing states (Delta, Edo, Ondo, Oyo, Osun and Ogun) are sold by plantain sellers (Bill and Melinda Gates Foundation, 2015).

The market mainly consists of fresh unripe and ripe plantain bunches, chips and flour. The fresh ripe and unripe plantain is consumed either at the level of the household, or processed by road side vendors or restaurants. Plantain is consumed everywhere in Nigeria, although more prevalent in the southern belt of the country. Similarly, through the key informant interviews, it was identified that plantain is a more important staple food in the South South than in the South West. A variation in the demand is that people in the South South consume more unripe plantain (predominantly as plantain porridge and boiled plantain) while people in the South West consume more ripe plantain (predominantly for roasting and frying), although roasted ripe plantain is also very popular in the South South. Besides the fact that plantain flour is traditionally processed by villages in the South West, plantain flour is becoming in higher demand by urban middle class as a healthy alternative for

semo or *gari*. Unripe plantain flour is indeed known for its high level dietary fiber content and relatively high level of resistant starch (e.g. Agama-Acevedo *et al.*, 2019; Giraldo-Toro *et al.* 2015). This increasing demand leads to an increase in processing centres especially in Nigeria's South West. In Lagos alone are 2000 small-scale plantain chips processors and several medium-scale plantain chips businesses.

Chips are also increasingly popular. They are mostly sold by road side vendors to people in transit and consumed on the go. In some cases, although chips are appreciated by everyone, chips consumption is related to young people such as students and travellers who look for a quick snack to keep them going (key informant interview with Kayode, 7 May 2019, Ibadan).

Generally, although plantain is consumed everywhere and by everyone, most plantain is shipped to urban centres where the demand is high due to a higher concentration of people. Depending on people's financial capabilities, people who can afford it may buy a whole bunch while others may buy only a few fingers at a time. Preferred characteristics for plantain products can be found at individual or household level. According to key informant interviews, some people prefer their *dodo* to be prepared at a different ripening stage, influencing the softness of the end product. Similarly, boiled plantain and *boli* may be prepared with plantains at different ripening stages and different cooking times, depending on individual preferences (key informant interview with Adeboyejo, 13 May 2019, Ibadan).

3.1. Value chain and transport

The transport of plantain starts with its harvesting at the right stage of maturity. Locally marketed plantains can be harvested at a more advanced maturity stage compared to export market fruit that should be harvested preferably on the day of shipment. After harvest, farmers either display their crop by the roadside or they transport it to markets in the vicinity. The fresh plantains that are sold on these open markets or farmgate are purchased by aggregators/assemblers. A value chain analysis of plantain in Ondo shows that apart from selling fresh plantain on the market or at the farmgate, it is also common that the wife of a farmer takes the plantains for roadside marketing, either fresh or processed into chips, dried plantain or roasted plantain (Adewole, 2017). During the key informant interviews it was confirmed that women are mostly engaged in transport of plantain bunches when the transport is done by foot. Women transport them to nearby markets and sell them to (mostly) market women there.

Apart from aggregators or assemblers who buy plantain along the roadside or on village markets, there are also aggregators who buy the fresh plantains from farmers directly. The farmgate assemblers handle around 55% of all plantain production. Buying plantain from farmers at the farm gate is cheaper, because assemblers avoid farmers from bargaining for higher prices which is happening when plantain is taken to the market (Ayanwale, 2016). During the key informant interviews, most actors in the plantain value chain confirmed that these aggregators are mostly women, although it is also possible for men to be involved in the aggregation of plantain.

According to literature (Ayanwale, 2016), plantains are sold to wholesalers by the assemblers. There are in situ and transit wholesalers. In situ wholesalers resell the plantain immediately in the same market (they market around 2 tonnes per 5 days), while transit wholesalers transport plantain to cities (they can market 6-8 tonnes of plantain per 5 days). Although key informants spoke more about in situ wholesalers, they emphasised women are dominant in situ and transit retailers. Processors buy the fresh plantain either from aggregators or from wholesalers. It is from the processors and wholesalers that the fresh or processed plantain goes to retailers and vendors who sell the plantain to consumers.

Speaking to different key informants, there did not seem to be a difference between transit wholesalers and aggregators. Rather, those (mostly women) who buy plantain either at the farm gate or in village markets transport plantain to nearby cities where the plantain is sold to retailers (market women who sell plantain fingers) or plantain processors (such as *boli* vendors) and restaurants. There are also aggregators who, after buying from the source, transport and sell plantain in major urban centres, mostly the markets *May12* in Lagos, and *J* in Benin City.

In key informant interviews it was explained that processing of plantain generally is not done by those who produce plantain. Instead, there are processing centres in villages and strategic axes (such as Ughelli in Delta State and Ogere in Ogun State), where generally women gather to produce for example chips. These are transported to cities and urban centres (where demand is higher due to population density) and sold to (roadside) marketers (key informant interview with Dr. Akinyemi, 7 May 2019, Ibadan).

The transporter is an important actor in the plantain value chain, and found at different levels. The transport of plantain is by road, mostly in pick-ups and small trucks. On larger distances, lorries and trailers are used to transport plantain. Transport poses a major threat to the quality of plantain, and post-harvest losses are high (40%) (Olorunda, 1996). This is mostly caused by the bad road conditions, rough handling, piling of the bunches, and poor transport conditions (no packaging/protection of plantain). Transport costs are generally high, but due to high plantain prices (a bunch of plantain sells between N500 and N1,500 which translates to 1.38 to 4.14USD) all players along the value chain can earn a healthy margin.

Another major challenge in the plantain value chain is storage. After harvesting, bunches are often taken to a collection area where they are piled on top of one another. At this stage, grading takes place to eliminate diseased, damaged or over-ripe fruits. The assembly of plantains preferably takes place in a shaded area that is close to the road for transport. Sun, rain and wind should be avoided, since temperature and humidity can cause damage to the plantain and affect shelf-life. Storage facilities are generally poor. This, in combination with ineffective post-harvest treatment of fruits makes up for a loss for those engaged in the marketing of plantain. A study on indigenous ripening technologies suggests that whereas out of an estimated 17% economic loss, 14% is assumed to come from the South West and only 3% from the South East. This is related to the use of ripening technologies by mostly women in the South East: most commonly, plantain fruits are kept in wooden boxes, pots, baskets, drums, polyethylene bags, jute-bags, and clothes, under a natural cool-dry environment. To speed up the ripening process, carbide enclosed in plastic can be placed in one of the different aforementioned containers. Also, inclusion of African bush mango fruits with the plantain fruits speeds up ripening. Other methods are spraying of cold and warm water before storage. These techniques are often used by traders who want to sell their plantains to consumers as soon as possible after purchase.

4. PLANTAIN CONSUMPTION AND PREFERRED CHARACTERISTICS

In most West and Central African countries, plantain is consumed as an important part of the meal. Plantain can be eaten at different ripening stages (roughly categorized as unripe where peel colour is completely green; ripe where peel colour is completely yellow; or over-ripe where peel colour is yellow with big black patches) and is processed into different food products. Plantain is fried, boiled/cooked and roasted/grilled. The processing of plantain is necessary to make it more palatable and digestible (contrary to sweet desert bananas that can be consumed directly).

4.1. Plantain processing and preparation

The main processing techniques applied to plantain in West and Central Africa are boiling, roasting and frying. Although these are most common practices across West and Central Africa, there are regional differences in the preparation of plantain. In Nigeria, plantain is used at different stages of ripening. The unripe fruits are peeled, sliced, dried, milled into flour and consumed as 'plantain *amala*'. The mature fruits (ripe or unripe) are consumed boiled, steamed, baked, pounded, roasted, or sliced and fried into chips. Overripe plantains are processed into beer or spiced with chili pepper, fried with palm oil and served as snacks ('*dodo-Ikire*'), especially popular around Ikire, Osun state. Industrially, plantain fruits serve as composite in the making of baby food ('*Babena*' and '*Soyamusa*'), bread, biscuit and others (Akinyemi 2010).

As confirmed during the Key Informant Interviews, plantain is consumed in various forms in Nigeria, with considerable differences between South East and South South Nigeria. *Boli* is a snack (normally found along the road side) widely consumed across all Nigerian states. *Boli* is prepared by placing fingers at ripening stage 3 or 4 on a gridiron above charcoal. The plantains take around 30 minutes with frequent turning to brown evenly (Kouamé, 2014). Although consumed with different condiments across the regions, the preparation process is the same.

Dodo is a popular dish prepared and consumed mostly at home or in restaurants. *Dodo* is best prepared with plantain at ripening stage 3 to 5, which is subjective to individual taste preferences, more than regional differences. In some cases, the softness of the *dodo* is influenced by the accompanying dish. A key informant explains 'I will eat the plantain that is still hard with egg. But if I want to eat it with rice, I want to fry one that is a bit riper already' (key informant interview with Usigbe, 7 May 2019, Ibadan). For making *dodo*, plantain is peeled, sliced lengthwise, horizontally, diagonally or into small pieces according to individual preferences, salted and fried. The duration of frying is dependent on the browning preferences of the consumer. Despite individual differences in preferences, all key informants indicate to make *dodo* with ripe plantain that is still firm when touching it. Upon frying, it needs to stay firm and come out 'dry' (not oily). Across the regions, key informants were talking about a recently distributed Whatsapp message explaining that *dodo*, especially eaten in combination with beans is not well digestible and therefore not healthy. Generally, health awareness seems to lead to people eating less *dodo*.

Plantain is also popularly boiled, especially in the South South of Nigeria. For the boiling of plantain, ripe or unripe, plantain is peeled and boiled for around 30 minutes. Ayanwale et al. describe that after removal of the peel, the pulp is soaked in salty water for 5-10 minutes prior to cooking, in order to reduce the bitter latex in plantains (Ayanwale et al. 2016). For boiling of plantain it is important that the plantain is not overcooked, as to prevent the plantain from becoming watery and soft. Studies have shown that hybrids have shorter cooking time (10 minutes) to prevent loss of firmness or softness (Dzomeku, 2007). Boiling is either done with or without the peel, depending on personal preferences. Key informants explain that traditionally people used to cook the plantain with the peel, which is known to preserve some valuable nutrients. This knowledge is not widely known anymore, meaning that many younger people find it neater to cook the plantain after peeling. The plantain is boiled for 10 – 15 minutes until soft. Both ripe and unripe plantain can be boiled, although boiling of unripe plantain is more common. The making of pounded plantain follows the same process, after which the boiled plantain is pounded to a smooth paste in a wooden mortar. In the South South, some people like to add cassava starch or *gari* to the pounded plantain to make it firm enough to *swallow*. Another, more modern method used by one of the key informants, is blending unripe raw plantain using a blender, after which it can be cooked into *swallow* (i.e. a *fufu* like substance that is refined enough to swallow without chewing) for consumption.

Flour is traditionally produced by drying unripe plantain slices (ripening stage 1 or 2) in the sun. This practice is especially common in the South West due to climatological reasons. On a more industrial scale, ovens or dryers can be used to speed up the drying process and to better control external factors that may affect the quality of the flour (such as temperature and dust). Before drying, the plantain can be treated with warm water or an emulsion to avoid oxidation. Upon milling, this produces a yellow/white flour that is attractive to consumers. A commercial flour miller in Ife was interviewed as one of the key informants. Although she is also a farmer, she did not have varietal preferences for the making of flour. The only difference that she noticed is that some flour comes out creamy yellow, while some flour is grey white. She preferred the yellow colour, but she explained that upon preparation no difference can be found between the two, and also that most consumers are unaware of this difference. At the level of farmers, some plantain is processed into dried chips for direct sales to consumers who mill it themselves. Key informants in the South South explained that, depending on individual preferences, people may also dry the peel (which is done separately from the pulp), and mix in a maximum of 20% plantain peel into the flour. This is mostly done for the health benefits of the peel, which are believed to have deworming and anti-diabetes qualities on top of a high mineral content. Plantain peels are known for being rich in total dietary fibre, vitamins (folic acid) and minerals (potassium) (Arun et al, 2015). If well prepared, plantain flour gives a brown (not black) *swallow* (i.e. a *fufu* like substance that is refined enough to swallow without chewing).

Plantain chips are produced by frying thin slices of plantain at ripening stage 1 or 2 in oil. There are different ways in which the plantain can be cut after peeling. Industrially, to make chips plantains are sliced in thin round transverse sections, while locally they are generally sliced lengthwise. Apart from salt, plantain chips can be spiced with pepper or onion powder after frying. The preparation method for plantain chips is similar across the regions.

Processing of plantain (mostly into chips and flour) is becoming increasingly popular in Nigeria, and represents around 18% of total production. To sell plantain flour in Nigeria or even export the product abroad, the investor would have to register with the National Agency for Food and Drug Administration Control (NAFDAC) in Nigeria and as such the promoters would have to ensure that the production meets good quality standard by ensuring stringent and hygienic condition prevail at the production plant².

4.2. Preferred characteristics

Due to the wide variety of cooking methods for plantain, the **texture** and **softness** of the cooked plantain are important traits for a good plantain cultivar. The choice for a particular method of cooking or processing is partly based on the textural properties of the variety. It is therefore important that a plantain cultivar suits the various uses of cooking (Dzomeku, 2007). **Variety, maturity and ripening stage** of the plantain are main determinants for the quality of the end product. The concepts of maturity and ripening are often used interchangeably for plantains. However, they can be distinguished since plantains are climacteric fruits which mature before they ripen. Physiologically, maturity is linked to how well the fruit is filled with pulp (developed) while ripening is closely linked with the changes in peel colour and the conversion of starch into sugars so the fruits become sweeter and softer towards senescence. When to harvest a fruit is determined by maturity indices which are adopted depending on variety and purpose for harvest. Generally for plantain a sure determinant to know that the bunch is mature is that a fruit of the first hand starts to ripen (change colour from green to yellow). Others judge by angularity of the fruits. Once a plantain bunch is deemed to be mature, it is harvested. If it starts to ripen and it is not harvested, the ripe fruits will be eaten by birds and/or rodents. Once harvested the plantain can either be used at that stage or kept to ripen to be used at a later stage. Different ripening stages can be distinguished: stage 1 (green maturity stage), stage 2 (light green), stage 3 (half yellow), stage 4 (more yellow than green), stage 5 (yellow with green tip), stage 6 (full yellow), stage 7 (yellow with black spots), to stage 8 (all black) (Kouamé, 2014). The variety and ripeness inform how the plantain can best be processed. Besides the colour of the peel, the ripeness is also assessed by the pulp colour of the plantain. The fruit is considered mature when the pulp is yellow and immature when the pulp is white (Dzomeku 2007, Kouamé 2014).

A study on plantain preferences in Ivory Coast shows that ripening stage is generally decisive in the choice of the use of the banana, while the characteristics of the fruit (such as size, appearance and shape) have no significant influence on consumer choice. Contrary to the latter, a study on consumer preferences in Ghana shows that hybrid BITA-2 (cooking banana) was rejected due to finger size and length. The study in Ivory Coast also shows that interviewees clearly expressed culinary preferences for specific plantain varieties. Four cultivars of plantain were available on the market in Ivory Coast; patregon, Ameletiha, Agnrin and Afoto. The Afoto cultivar is the most available. At stage 2 it is the variety mostly used for roasted plantain. Generally, Ameletiha at stage 3 and 7 is most preferred by consumers. At stage 1 it is most used for processing of chips, and at stage 8 it is used for *doclou* or *klaclo* (spicy plantain fritters). Both Ameletiha and Agnrin at stage 3 and 4 are most preferred options for *futu*, pounded plantain. The Agnrin variety at stage 6 and 7 is mostly used for *aloko* (fried plantain). Apart from variety, the choice of the processing method also depends on the stage of fruit ripening, showing that households clearly distinguish cooking methods that are suitable for the specific variety and ripening stage (Kouamé 2014).

A study of consumer behaviour among the urban population in Yaounde and Douala in Cameroon shows that the maturity of the fruit is the most important quality determinant (Durya, 2001). Maturity

² [https://agribiz.info/agriwiki/article/plantain-value-chain/#What BUYERS look for when buying plantain](https://agribiz.info/agriwiki/article/plantain-value-chain/#What_BUYERS_look_for_when_buying_plantain), accessed on 23/04/2019

can be evaluated by the filling/roundness of the fingers and the pulp colour. Apart from maturity, plantains should look fresh and bright to show that they have been transported under favourable conditions. The article also emphasises that the food product to be made from plantain determines the quality criteria and cultivar that people look for. For each food product, women could also name an unsuitable plantain variety. According to the article, plantain chips and fried plantain can be prepared with the widest variety of plantain cultivars. Although preferred characteristics for plantain are not specified, there are several unsuitable characteristics mentioned. Most frequently mentioned were long cooking period and white pulp colour, followed by colour change during cooking and peeling difficulties. Only few people mentioned taste problems, the presence of stones and a too soft consistency as less preferred characteristics (Durya, 2001).

Apart from texture, maturity and variety, **taste** and **flavour** play a role in cultivar selection in eastern Democratic Republic of Congo (Ekesa, 2012). In a study done on banana and plantain cultivar preferences, flavour/taste, juice quality, resistance to disease and bunch size were the most important criteria for cultivar selection. Also in a study on consumer preferences in Kwara State, Nigeria, fruit taste is considered the most important parameter at purchase, together with size and number of fingers. Appearance, color and shelf-life are considered less important. Consumers preferred fingers of medium or big size, hands containing 9-12 fingers, pulp with light yellow color, absence of black spots in the peel, firm texture, aroma and flavor of medium intensity, medium sweet fruits and a shelf-life of 7-9 days under natural conditions (Folorunsho, 2010).

According to the various Key Informant Interviews conducted in Nigeria's South West and South South, fruit and bunch size is the main attraction for both marketers and consumers. Plantain is most appreciated when bunches contain many fingers and when fingers are large and thick in size. Contrary to the findings in Ivory Coast and Cameroon, variety does not seem to play a role in fruit preferences nor processing method. The most common plantain variety in Nigeria is the landrace *Agbagba*. A few key informants have experience with improved varieties. Key informants explain *'we have plenty local plantain varieties, up to 10. They can all be used for different food products. For frying you can use any plantain, agbagba or any other variety including PITA 14. For boiling you can use any plantain at any ripening stage. Cooking banana is the best for diabetes, because it is acidic. FHIA 25 and cooking banana have the same content. Cooking banana is very cheap, you cannot use it for boiling or eating raw, because it is acid like FHIA 25. But it is good for frying'* (key informant interview with Adjarho, 29 May 2019, Agbarha). Most improved varieties are not widely accepted due to morphological appearance, softness of the pulp, low market value, short shelf life, thickness of the peel, or the non-sweetness of the taste. A key informant explains that farmers cope with the low acceptability of improved varieties by processing it into flour, after which it is difficult to distinguish variety (key informant interview with Dr. Ayanwale, 16 May 2019, Ife).

A key informant explained the lack of varietal preference by the fact that some popular plantain products (like plantain chips) are relatively new, meaning there are no longstanding traditional practices related to variety selection (key informant interview with Aman Omondi, 17 May 2019, Ibadan). Apart from the improved varieties, all popular varieties can be processed into any of the plantain products. Next to size, maturity and ripening stage are the most crucial quality characteristic of the raw product according to all key informants. Although there is some varietal influence, maturity is largely related to the colour of the pulp, which is generally yellow when mature and white when immature. Consumers generally look for plantain with yellow pulp. The ripening stage is the main determinant of the processing method and the plantain product it can be used for.

4.3. Regional differences

It is assumed that there are different plantain consumption patterns in rural and urban areas. However, little is known about the popularity of *dodo* and other plantain products in the countryside and urban areas. This scoping study found that there are distinctive processing methods and food preferences across the sampled regions. A key informant from Ondo State explains *'food is very cultural for us, cultural means geographical. The way Igbo's eat plantain is different. Even the menu and recipe differs'* (key informant interview with Dr. Adeboyejo, 13 May 2019, Ibadan).

Dodo is popular across all demographic groups in the South West (including rural and urban areas) and is eaten mostly as a side dish accompanying rice, beans and stew. Although *dodo* is eaten across rural and urban areas, key informants stress that *dodo* is more popular in urban setting. *‘I have a plantain farm and I discovered that if you are the one planting, you will boil plantain more. Because you just go outside and pluck them. It is easier and faster to boil them than to fry. Frying takes more time. For frying you need to stay there. And health wise, frying is discouraged. So people that plant, the smallholder farmers, they rather boil’* (key informant interview with Dr. Adebeyejo, 13 May 2019, Ibadan). Dr. Akinyemi further explains *‘people in rural areas do not eat much dodo, because it is not satisfying like boiled plantain that they eat with sauce. Boiled plantain is more filling after their farm work’* (key informant interview with Dr. Akinyemi, 7 May 2019, Ibadan).

Also *boli*, commonly found as a snack along the roadside in towns and cities is popular in both the South West and South South. In the Southwest *boli* is eaten with groundnuts, while in the South South people eat it with fish, red oil, pepper, and onion.

Apart from these popular products, plantain seems to be much more integrated in the consumption patterns of people in the South South. Whereas in the South West, people purchase mostly ripe plantain on the market, plantain is mostly consumed unripe in the South South. Unripe plantain is mostly used for boiled dishes, and is eaten either with soup, pepper soup or other condiments, as porridge (plantain pottage) or pounded into swallow. Key informants in the South of Delta State explain *‘in the South West people may fry plantain at home, but we don’t do that here. Traditionally we boil plantain, we pound it with garri. That is very common in our area. We also mix pounded plantain with starch to make it into swallow. We also use ripe plantain for boiling, we call it emieke. These are recipes that people mostly prepare at home. People in this area do not boil banana like in other parts of Delta’* (key informant interview with Mr. Adjarho, 29 May 2019, Agbarha). Pounded plantain is mostly consumed in rural areas, both in the South South and South West. Whereas pounded plantain is also consumed in the South East, pounded plantain is most common in the South South and sometimes mixed with cassava flour, flakes or fufu. In the South West pounding of plantain is not common in urban areas but only in rural areas (key informant interview with Dr. Akinyemi, 7 May 2019, Ibadan). Commercial farmer Robert Okrakpor explains *‘in this area we eat plantain as porridge. We use the flour to make something like semovita. You can pound it. People who have some diabetic problems, they prefer to eat the unripe one. You can also roast it, that is a delicacy. We eat it with beans. We also eat dodo when plantain is ripe. The other recipes are all made with unripe plantain. You can also combine the ripe plantain with plantain flour and make it into something similar to moi moi/okpa. But it is sweeter than moi moi. They blend it with the flour, they add red oil, crayfish, break the raw egg into it, they wrap it into plantain leaves or bowls. People eat most of boiled plantain with porridge or beans’* (key informant interview with Robert Okrakpor, 31 May 2019, Asaba).

The use of plantain flour is traditional in villages in the South West, where due to the climate, drying has been a good preservation method. Plantain flour is generally made into *‘amala’*. In the South South, where humidity is higher and drying therefore more difficult, flour processing is traditionally less common. Health consciousness plays a major role in the current upcoming popularity of plantain flour, especially among the health conscious, middle- and high-class urban population. Although slightly expensive, it is consumed as a healthy and less starchy alternative for *semovita* (*semolina* - from durum wheat- with added vitamins), *garri* or *poundo yam*.

4.4. Alternative uses

Apart from the processing of plantain into different food products, plantain peels can be used as feed for livestock and soap production. The dried leaves, sheath and petioles are used for tying, sponges and roofing. Plantain leaves are also commonly used for the wrapping, packaging, marketing and serving of food (Akinyemi, 2010). Also, during the key informant interviews, alternative uses of plantain were mentioned, such as wine/alcohol production, the use of the stem and root as local herb against diarrhea and treating of wounds, use of leaves for roofing, making of belts, mats and bracelets. Apart from these uses, there is also a market in the suckers of plantain. A value chain analysis in Ondo shows that 59.5% of the interviewed farmers sold suckers to other farmers, as additional source of income. The other 40.5% of the interviewed farmers did not sell

suckers and shared them or used them to increase their farm (Adewole, 2017). There is a big market in suckers that can provide a major source of revenue for farmers. One farmer in Delta North explains *'between May ending till August ending, people will come for 1000 - 5000 suckers each, although there are also people who come only for a few hundred suckers. The demand is mainly driven by drought'* (key informant interview with Robert Okrakpor, 31 May 2019, Asaba). Researchers at the University of Ibadan (UI) are currently also looking at the use of plantain for the production of starch. Dr. Adebojeyo from UI explains *'cassava starch is generally becoming industrially applied, instead of potato or corn starch. Cassava is also staple food for many people, especially rural resource poor people. That has made the staple food from cassava to become expensive. That is why we are looking at plantain starch as a substitute for cassava starch, to technically replace what cassava can do. So it will reduce the burden on cassava as staple'* (key informant interview with Dr. Adebojeyo, 13 May 2019, Ibadan).

5. CONCLUSION

Plantain is an important crop in different farming systems in the Southern, plantain producing belt of Nigeria. Men and women play different roles in the production of plantain, which is more male dominated in the South West, and more female dominated in the South South. There is increasing interest of commercial farmers in plantain production, which is in line with an increasing demand for plantain. The increasing demand is partly related to increased awareness of the health benefit of various plantain products, and therefore increased appreciation of plantain as food crop. This scoping study shows that the ripening stage mostly determines the quality of the plantain and informs the processing method. Apart from ripening stage, the bunch size (number of fingers per hand) and the finger size seem to be important quality determinants. The RTB foods WP1 end user survey will need to investigate possible other crucial quality characteristics that are not featured in this scoping study. Contrary to what is written in literature regarding the relation between the variety of plantain and the food product that it is best used for in, for example Ivory Coast, this relation seems to be absent in Nigeria. The scoping study reveals that generally, varietal difference does not play an important role in plantain production, processing and marketing in Nigeria. Although we assume to find more improved varieties in Delta State, there is little information about the acceptability of these hybrids, and their possible use for specific plantain products. This scoping study confirms that there are strong regional differences in plantain products. For example, fried plantain is more prominent in cities and there is an increasing demand for plantain flour. However, little is known about what people in different parts of Nigeria use plantain for and the importance of other plantain products for food security and income generation. Whereas women are to varying degrees involved in the production of plantain, women generally play a significant role in the processing and marketing of plantain and plantain products. At the same time, key informants explain that the control over revenue is mostly in the hands of the (male) producer, especially where no processing takes place. It has to be stressed that in this scoping study limited information was found on specific quality characteristics related to plantain products in Nigeria, the uses of plantain in Nigeria and the role improved hybrids play among end users. This affirms the importance and pioneering nature of the WP1 RTB foods survey work. To inform the breeding process, more detailed information is needed on possible varietal differences and their relation to different uses of the crop by different end users.

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Key informant interviews

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