IMPROVING FOOD SECURITY IN AFRICA THROUGH INCREASED SYSTEM PRODUCTIVITY OF BIOMASS-BASED VALUE WEBS *(BIOMASSWEB*)

DEMAND-DRIVEN RESEARCH AND DEVELOPMENT (DDRD) ACTIVITIES

TECHNICAL REPORT

DEVELOPING BIOMASS-BASED VALUE CHAIN OF PLANTAIN AND REDUCE POST-HARVEST LOSSES OF PLANTAIN THROUGH THE DEVELOPMENT OF VALUE ADDED PRODUCTS FOR SMALL SCALE FARMERS AND PROCESSORS IN TWO REGIONS IN GHANA

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List of Acronyms

AAAE	African Association of Agricultural Economists
AEASA	Agricultural Economists Association of South Africa
CSIR	Council for Scientific and Industrial Research
FAO	Food and Agriculture Organisation
FDB	Foods and Drugs Board
GEPC	Ghana Export Promotion Council
GSA	Ghana Standards Authority
IITA	International Institute of Tropical Agriculture
JASR	Journal of Agriculture and Social Research
MoFA	Ministry of Food and Agriculture
MSMEs	Micro-Small scale enterprises
NGO	Non-Governmental Organisation
SWOT	Strength Weakness Opportunities and Threat
VC	Value Chain

Summary

This baseline survey sets the benchmark for developing plantain biomass-based value chain with the aim of reducing post-harvest losses through the development and transfer of value added products. The survey sought to (i) identify the actors and their roles along the plantain value chain (ii) understand the plantain value chain activities, and (iii) identify value addition opportunities that will help reduce post-harvest losses of plantains.

Two key data collection methods were used: (i) one-on-one structured interviews and (ii) focus group discussions. A total of 309 plantain value chain actors including producers, processors, traders, caterers and consumers were covered in the Brong Ahafo and Western Regions of Ghana. Findings covered the biomass-based value chain assessments, gender roles, levels of post-harvest losses and identification of market potentials along the entire plantain value chain.

The study estimated post-harvest losses of up to 20% at the production, up to 15% at the market levels and less than 5% at the consumption level. The study found that plantains are traded mostly in the unprocessed form with about 83% of the plantains produced by the farmers interviewed sold unprocessed. Horizontal flow of the plantain commodity was prominent among actors with limited value addition at the processing level. By-products identified at the production level included leaves, stems/trunk, bunch and few peels with low utilization levels and basically left on the farm to decompose. Peels generated at the processing and consumption levels were used for animal feeding and soap making or disposed off in the refuse dump. Majority (70.6%) of the processors interviewed sold plantain peels for animal feeding. About 61.6% of the respondents at the consumption level used plantain peels to feed animals. About 35.7% of the respondents disposed plantain peels off into the refuse dump. Less than 1% of the respondents sold plantain peels for soap making.

The cross cutting constraints among the actors were inadequate credit accessibility, high transportation cost, limited processing capacities, seasonality of plantains and fluctuation in prices, marketing challenges and losses during among others. Some recommendations made include intervention in the area of linking actors in the value chain to prospective buyers, taking advantage of improved varieties and possibility of staggering planting to get plantain all year round and research to improve on the existing coping measures to control losses as well as promotion of existing and new processed products (products (plantain fufu flour, plantain flour for pastry products) and development of new products from by-products along the plantain value chain.

1.0 INTRODUCTION

1.1Background

Plantains and bananas (*Musa* sp.) are valuable starchy staples in Ghana. They provide a rich source of dietary energy (Strover and Simmonds, 1987) and also contribute to providing good quality diet and rural income (Ortiz and Vuylsteke, 1996). Plantain is a versatile food in the kitchen as well as a raw material for many popular delicacies and snacks (Aina *et al*, 2012). It contains about 35% carbohydrates, 0.2-0.5% fat, 1.2% protein, and 0.8% ash (IITA, 2009). it is rich in carotenes (pro-vitamin A), ascorbic acid and minerals, particularly calcium, potassium and phosphorus (Ketiku, 1973). Plantain also has high levels of iron (Fe), and zinc (Zn), which are important minerals for public health nutrition.

Processing of plantains into flour is limited as most plantain foods are eaten as boiled, fried or roasted. However, after the introduction on local and foreign markets of instant plantain *'fufu'* flours consisting of plantain flour and cassava starch, interest in plantain flours have been generated as by virtue of plantain high carbohydrate content and convenience for instant foods in urban and peri-urban areas in Ghana.

Plantains have the potential to contribute to strengthening national food security and decreasing rural poverty (Adejoro *et al*, 2010). Annual production of the crop has grown consistently increase, culminating in an increment of more than 1,000 MT over the past decade (Table 1.1). That notwithstanding, there are huge post-harvest losses which must be assessed to improve plantain production and processing. The Brong Ahafo and Western regions are the key production areas for plantains in Ghana.

Table 1.1 Production levels of plantain ('000MT)

Year	Ghana	Western	Brong Ahafo
2006	2900.0	530.8	635.9
2007	3233.7	542.7	871.8
2008	3337.7	558.1	882.1
2009	3562.5	584.5	952.4
2010	3537.7	577.1	980.0
2011	3619.8	510.5	1055.8
2012	3556.5	534.1	961.2
2013	3675.3	531.2	980.2
2014	3786.0	592.1	924.7
2015	3958.1	645.1	961.7

Overall, this project seeks to develop a biomass value chain of plantain and reduce postharvest losses of plantain through transfer of processing technologies to small-medium scale processors and create linkages between farmers and processors to new markets in Ghana. Some of the value added products targeted include instant plantain *fufu* flour; plantain composite flour for bread, cookies, cakes; plantain flour for traditional foods as *tatale*, *bofrot, togbee*; and deep fried plantain chips

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1.2 Objective

The objective of this survey was to (i) identify the actors and their roles along the plantain value chain (ii) to understand the plantain value chain activities (iii) identify value addition opportunities that will help reduce post-harvest losses of plantains.

Ultimately information obtained from this survey will be used to develop a Biomass-based value chain of plantain and reduce post-harvest losses of plantains through the transfer of plantain processing technologies of instant plantain *fufu* flour; plantain composite flour for bread, cookies, cakes; plantain flour for traditional foods as *tatale*, *bofrot*, *togbee*; and plantain chips as value added products to processors and small-medium scale processors and create linkages between farmers and processors to new markets in Ghana.

1.3 Methodology

The *BiomassWeb* is a research project designed to enhance food security in Africa by boosting effective and efficient production, processing and trading as well as enhance the utilization of food and non-food biomass through increased system integration of associated biomass value webs.

Biomass-based value chain assessments, levels of post-harvest losses and market potentials for plantain are assessed as baseline studies for production, marketing and consumption locations. Two areas including the Brong Ahafo and Western Regions were selected for this baseline.

Two key data collection methods including one-on-one structured interviews and Focus Group Discussions were used. A structured questionnaire was designed for the various value chain actors including plantain producers, processes, traders/sellers, caterers and consumers. Random Sample of Producers (72), Processors (17), Traders/Sellers (63), Caterers (40) and Consumers (117) were interviewed. Table 1.2 presents the summary of demographic background of respondents.

Figure 1.1: Focus group discussions

Table 1.2 Socio-economic/demographic characteristics of respondents

Categories	% Response				
	Farmers	Processors	Sellers	Catering Services	Consumers
Position in the Household					
Head	70.0%	35.7%	55.2%	39.3%	39.1%
Member/Dependent	30.0%	64.3%	44.8%	60.7%	60.9%
Sex					
Male	36.1%	0.0%	1.6%	13.2%	23.9%
Female	63.9%	100.0%	98.4%	86.8%	76.1%
Age					
Below 20	0.0%	5.9%	0.0%	0.0%	8.6%
20-29	14.1%	35.3%	4.8%	13.9%	34.5%
30- 39	18.3%	35.3%	33.9%	22.2%	27.6%
40 - 49	6.8%	17.6%	40.3%	36.1%	17.2%
Above 50	40.8%	5.6%	21.0%	27.8%	12.1%
Level of Education					
None	10.3%	11.8%	24.6%	2.9%	7.2%
Primary	39.4%	11.8%	39.3%	11.4%	13.5%
Secondary	57.4%	76.4%	36.1%	57.1%	33.2%
Tertiary	2.9%	0.0%	0.0%	17.1%	24.3%
Others	0.0%	0.0%	0.0%	11.4%	1.8%
Marital Status					
Single	9.9%	17.6%	4.9%	6.2%	54.9%
Married	83.1%	76.5%	88.5%	81.1%	38.9%
Widowed	0.0%	0.0%	4.9%	0.0%	0.0%
Other	7.0%	5.9%	1.7%	2.7%	6.2%
Experience					
Less than 1year	1.5%	0.0%	3.6%	17.6%	Not
1-2 years	4.5%	40.0%	7.1%	2.9%	Applicable
3-4 years	24.2%	20.0%	17.9%	2.9%	
Above 5 years	69.8%	40.0%	71.4%	76.5%	

Source: Compilation by Authors, December 2016.

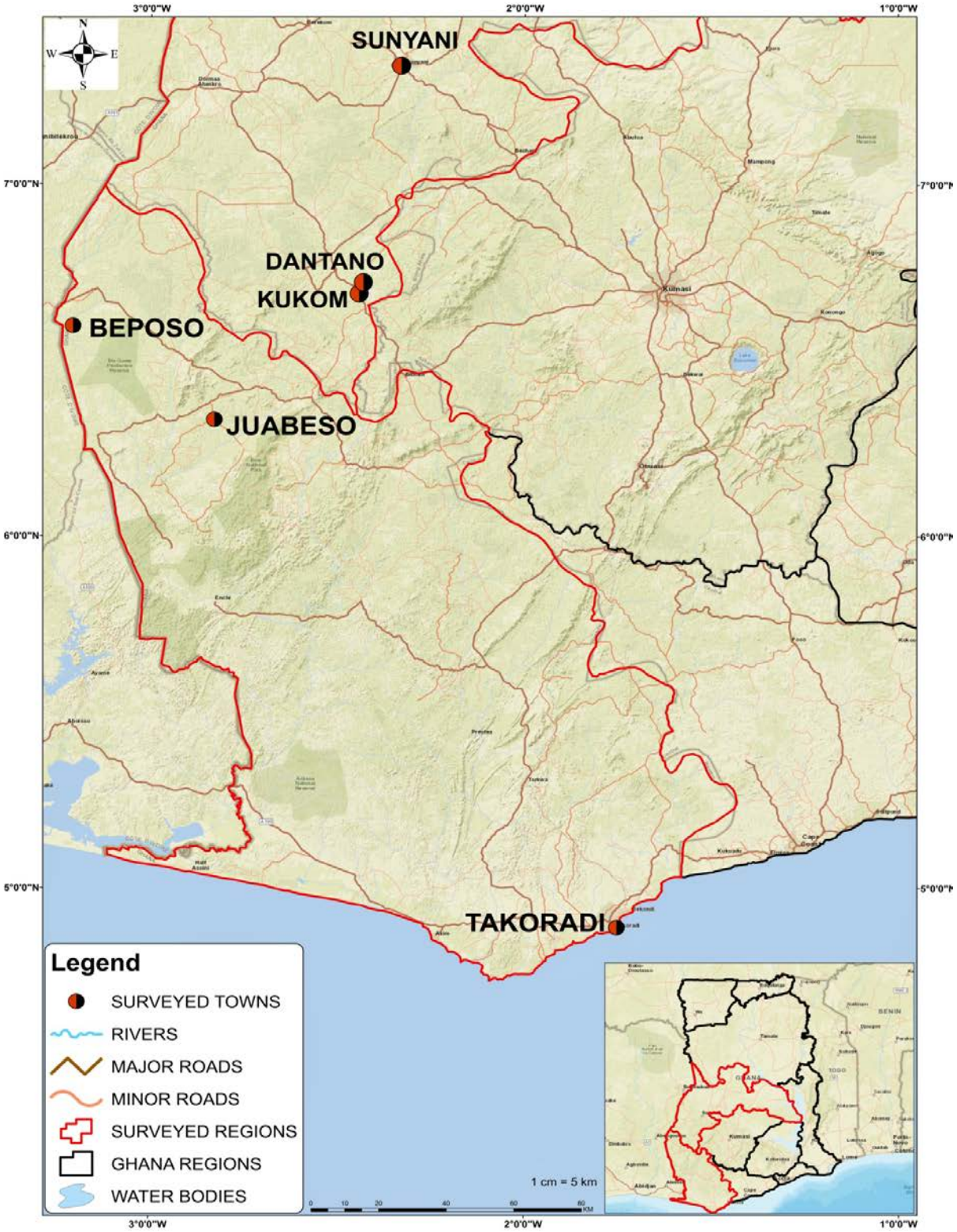


Figure 1.2: Study locations

2.0 FINDINGS ON PLANTAIN PRODUCERS

2.1 Plantain Farming System

In both plantain growing hubs, inter-cropping was widely practiced. The farmers cultivate plantain with other crops such as cocoa, cocoyam, cassava, yam, garden eggs, pepper and maize. As indicated in Table 2.1, 95.1% of the famers crop plantain with at least 2 other crops (tubers, vegetables or cereals). The remaining 4.9% grow plantain with only cocoa on the same parcel of land. This result corroborates a previous study by Dankyi et al 2007, who found that more than 90% of plantain farmers in Ashanti, Brong Ahafo and Eastern regions practice intercropping in plantain production.

Table 2.1 Plantain Farming System practiced in the surveyed areas

Other crops	Frequency	% Response
With Cocoa only	3	4.9
With Cocoa and Other crops(cocoyam, yam, cassava)	25	38.5
With Cocoyam, Cassava, Yam	24	36.9
With Cocoyam, Cassava, yam and Vegetables	11	16.9
With Cocoyam, Cassava, Yam and Maize	2	3.1
Total	65	100.0

Source: Compilation by Authors, December 2016.

Land tenure was similar in the two growing hubs visited. Generally family lands were used for plantain production in these areas. A few farmers, however, owned the parcel of land for plantain cultivation. A majority of farmers were found to operate on a small scale level, with a farm size of less than 5 acres (Table 2.2). Those with farm sizes of more than 5 acres, who could be considered as operating on a medium scale, constituted 28.6% of farmers interviewed.

Table 2.2 Scale of Plantain Cultivation (Farm Sizes) by Farmers interviewedFarm Size (acres)	Frequency	% Response
<2	17	24.3
2-5	33	47.1
>5	20	28.6
Total	70	100.0

Source: Compilation by Authors, December 2016.

2.2 Plantain Varieties Cultivated

Plantain varieties cultivated by farmers interviewed include, Falsehorn (*Apentu*), French plantain (*Oniaba*) and *Apem.* Others varieties mentioned were *Brode hemaa (improved variety), Sibosibo, Nyimantia, Asamienu, Asamiensa, Kaamenko , Akankuma and Kokuo ntrowa (traditional lanraces).* The predominant varieties grown, however, were *Apentu*, *Apem* and *Oniaba*, which are all landrace varieties. As shown in Figure 2.1, each farmer cultivated more than one variety. The farmers indicated that no improved plantain variety has been introduced to their catchment area and therefore they largely relied on these traditional varieties. However, they revealed their readiness to adopt new or improved cultivars of plantain which will improve their sales and profit margins.

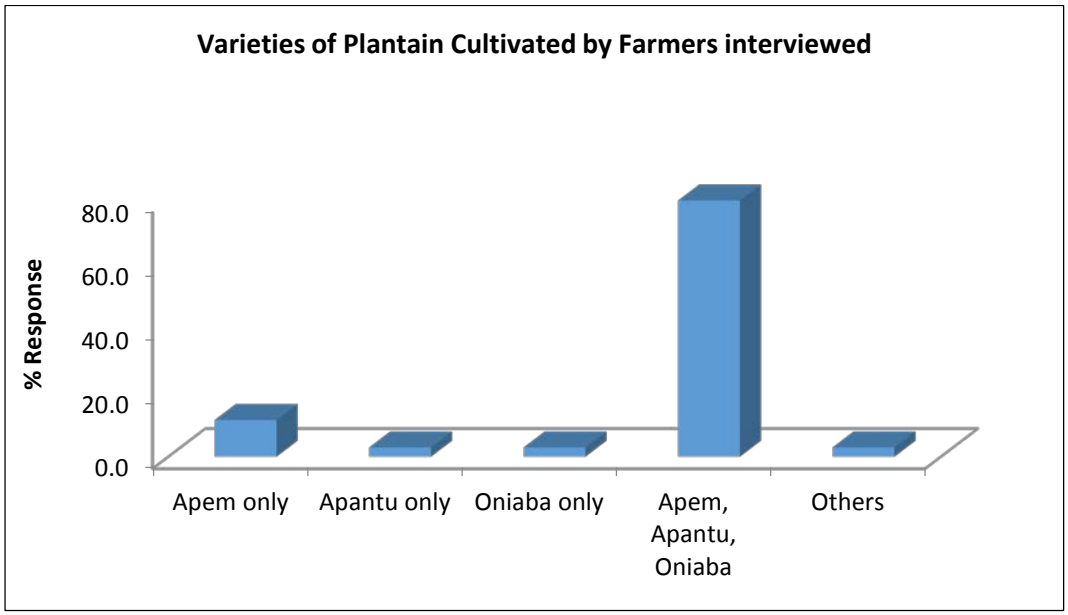


Figure 2.2 Varieties of Plantain Cultivated by Farmers interviewed

According to the farmers the most influential factors that decide the varieties grown are acceptability, pricing (profit margin) and maturity period. Other determinants mentioned, which are primarily based on the properties of the crop, include shape, size, color and storage properties (Figure 2.2).

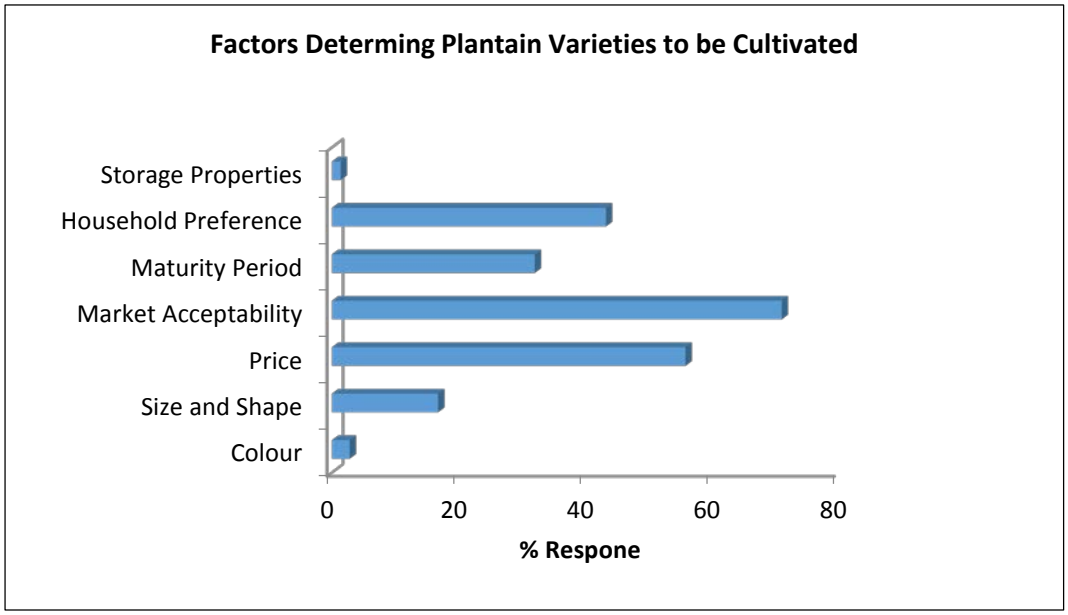


Figure 2.2 Factors influencing types of Varieties of Plantain Cultivated by Farmers

2.3 Harvesting

Plantain is available all year round but the peak harvesting season starts from August/September and ends in January/February. The lean season for plantain occurs in March-July. Generally, harvesting period is dependent on the time of planting and the maturity period of a particular variety. For example, the farmers revealed that *Apentu* matures 6 mo after planting, whereas *Apem* matures 9 mo after planting. The variations in the time of harvesting for the predominantly grown varieties are shown in Table 2.3.

Table 2.3 Varieties cultivated and maturity periods

Variety	Maturity	Month of Harvesting
Apem	9 Months after planting	October/November
Apantu	6 Months after planting	October-December
Oniaba	9 Months after planting	November-December

Source: Compilation by Authors, December 2016.

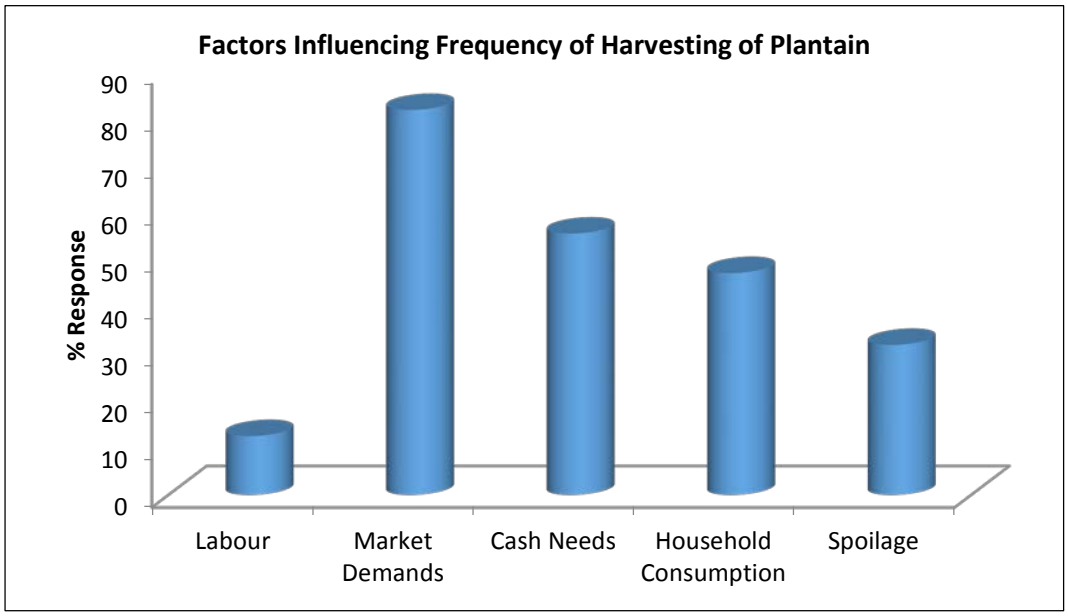


Figure 2.3 Factors influencing harvesting by Farmers

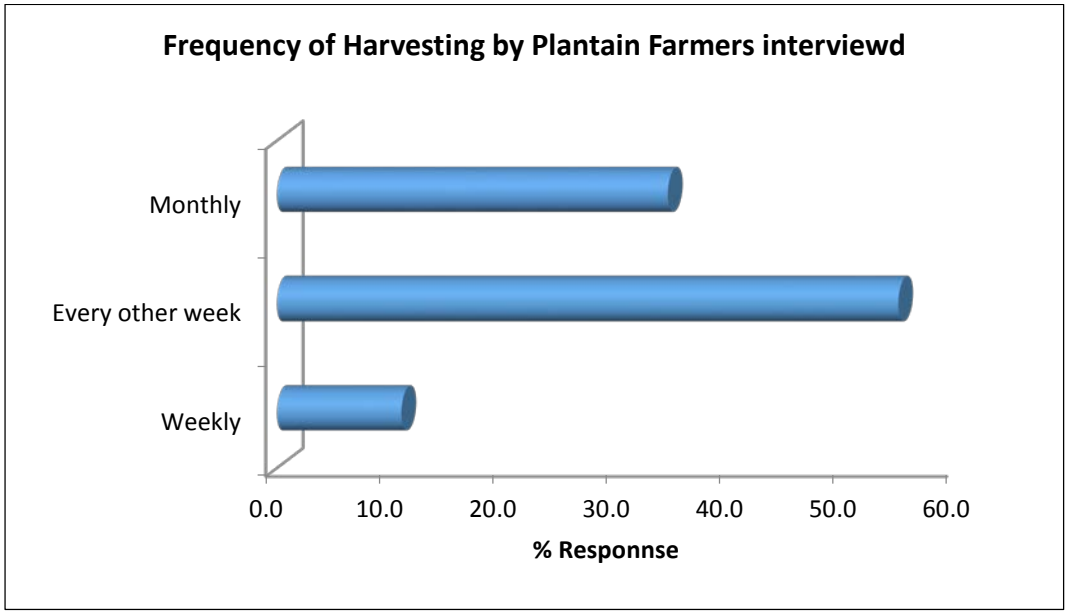


Figure 2.4 Frequency of harvesting by Plantain Farmers Interviewed

About 70% of the respondents indicated that labour was available for harvesting. Harvesting and bulking of plantain were done by the farmers themselves with their family members as indicated by 87.1% of respondents. Only 12.9% of the farmers interviewed used hired labour for harvesting. The cost of hired labor, in this case, is passed onto the "buyer"/customer".

According to farmers, hired labourers are not given an elaborate training on harvesting. The laboureres are only cautioned not cause any form of mechanical damage to the crop during harvesting. Most of the plantain farmers (80%) intimated that they grade their harvest according to size, maturity. Partially or fully ripe fingers are also segregated during bulking in order for ripening not to spread through the whole harvest.

Descriptive statistics showed that on the average, 83% of the plantain produced by the farmers were sold. This suggests that plantain cultivation in the surveyed areas is an income generating activity and harvested produce are sold largely in the unprocessed form.

Although, the farmers interviewed were highly influenced by the market dictates they also considered household food security demands. As shown in Figure 2.4, about 52% of the farmers interviewed consumed less than 10% of their produce, 29% of the farmers interviewed consumed between 11-20% of their produce.

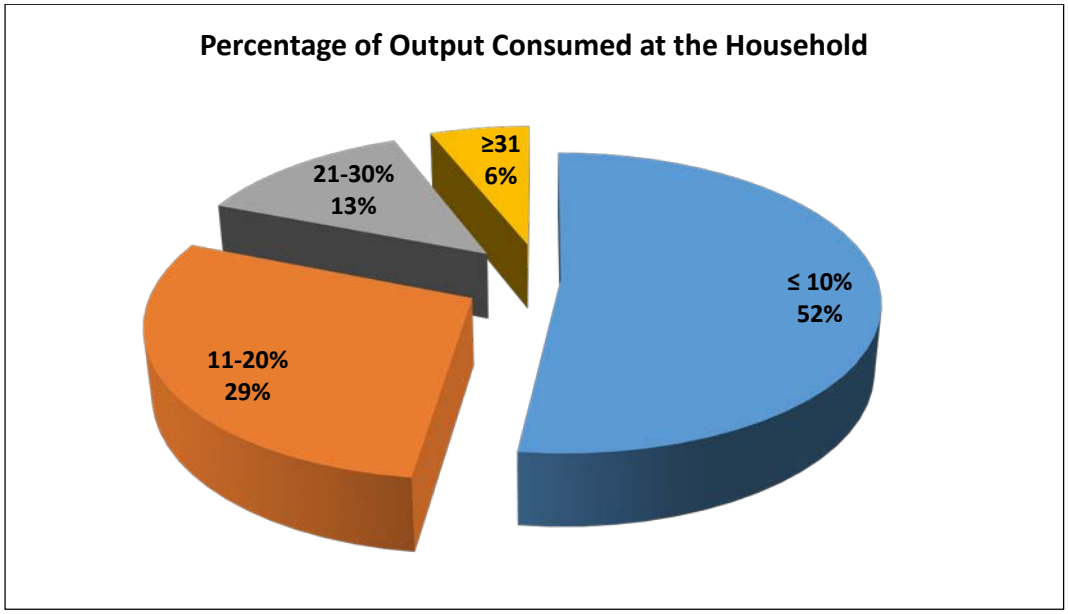


Figure 2.5 Percentage of Farmers Output Consumed at the Household

2.4 Storage

Storage of plantain varied among the farmers. After harvesting, plantain is left in the open field/farm, open storage in the house, kept in the kitchen or stored on the veranda in the house. Farmers interviewed mentioned that constructing a storage barn for plantain will cost up to GHS600.00 or approximately US$150.00 but this was hardly done.

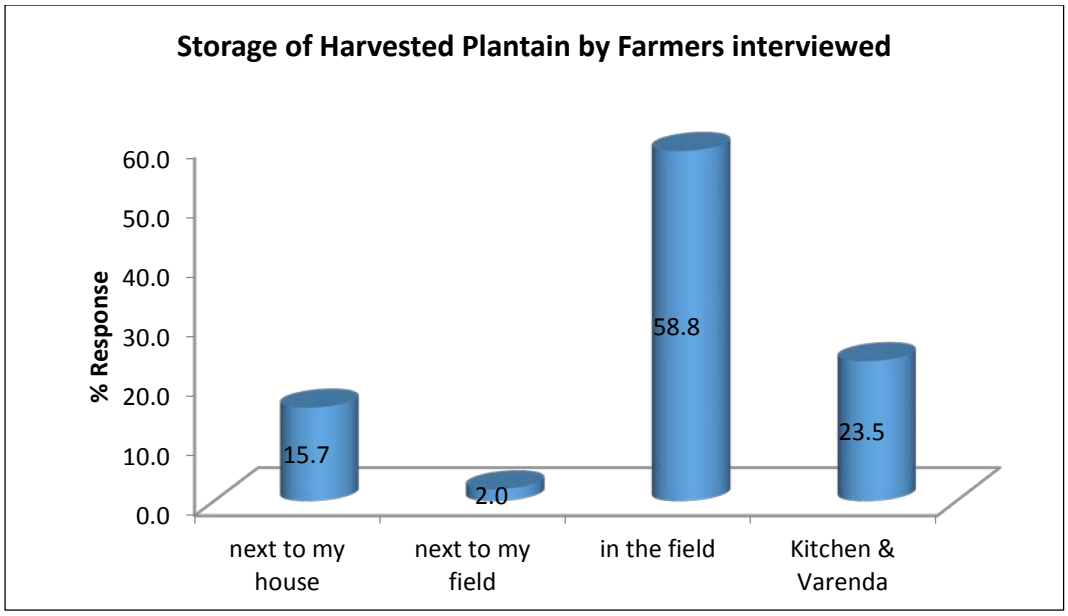


Figure 2.6 Place of Storage of harvested plantains by farmers interviewed

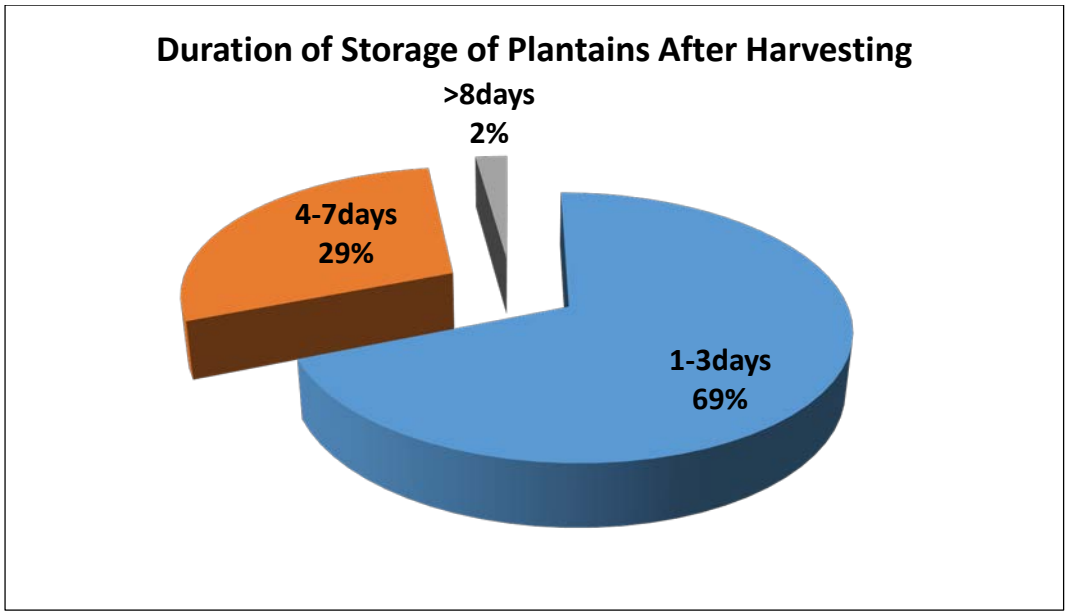


Figure 2.7 Duration of storage after harvesting of plantains by Farmers interviewed

Nearly 50% of plantain farmers interviewed indicated that storage periods differ with varieties. They opined that *Apem* stores longer than other varieties such as *Apentu* and *Oniaba*. Aside of the portion allocated for household consumption, plantain farmers themselves hardly store their harvest. According to 52.4% of the farmers, traders usually buy directly from the farms, bulk them at the same location before transporting to the market

place. They reported, however that in situations where the means of carting transportation fails, they are forced to store their produce on the farm for 1 day or 2. The proportion of harvest earmarked for household consumption are usually kept in a cool place, away from light.

Methods of spoilage prevention and or ripening control, as revealed by the farmers are not dependent variety. To the farmer ripening constitutes a loss because it reduces the income accrued from harvest. Farmers controlled ripening of plantain through the following:

- Cover with plantain leaves
- Cut, sort and keep in a cool place
- Cut the ones that are not very ripe
- Early harvesting and store in cool places
- Harvest at the right time
- Harvest it when not over matured
- Harvest promptly and regularly
- Harvest immature plantain & separate ripe plantain from unripe
- Keep in an open, sprinkle water on it in the evening
- Leave it on stem
- Sell immediately
- Sell product before ripping
- Spread out and keep in the field
- Twist the fingers on the bunches
- Watering of bunches, early harvesting, avoid heat

Generally, farmers try to control ripening of plantain after harvesting as previously mentioned. However if it happens, ripe plantains are either reduced to sell, sold at the same price as green plantain, given away as gifts or consume in the house or processed for sale. The latter was practiced by a few farmers. Table 2.4 presents results of farmers response to the question on what was done to ripe plantains.

Table 2.4 What was done to ripe plantain by farmers interviewed

Description/item	% Response
Reduce to sell only	6.5
Give away as gift and consume in the house	19.4
consumed in the house only	16.1
Reduce to sell and give away as gift	8.1
Reduce to sell and consume in the house	12.9
Sell at the same price and consume in the house	1.6
Multiple choices	35.5

Source: Compilation by Authors, December 2016.

About 35.5% of the farmers interviewed did more than two combinations of the choices and hence were categorized as stating multiple choices. This was followed by those who gave away as gifts and consumed in the house constituting 19.4%. Those who consumed in the house only constituted 16.1% while 12.9% of the farmers interviewed reduced to sell and consumed in the house.

Level of Losses

Level of losses during storage ranged from 1% to 20%, with an average of 4%. The level of loss was established to vary by plantain variety. For example, whereas *Oniaba* starts rotting early, *Apem* has better keeping quality and takes longer to ripen, *Oniaba* begins to show signs of ripening after about 3 days in storage. Sources or causes of losses observed were as follows:

- Over matured & over ripe plantain
- Heat during storage
- Rodent attack
- Other Pests & Birds
- Breakages during harvesting and storage
- Use of unskilled labour during harvesting/Improper harvesting
- Late harvest
- Ripening and rotting
- Theft
- When there is no market

Farmers usually carry out the following preventive measures to limit the level of loss

- Early harvesting
- Give it out
- Harvest early or timely
- Harvest promptly, Hold while cutting
- Harvest regularly
- Keep in a cool and dry place
- Process to *kakro*
- Sell it immediately
- Sell it when it ripes
- Space out and spread on floor
- Use of skilled harvesters

2.5 Marketing

Plantain was sold fresh after harvesting. Only 1.4% of the farmers interviewed were involved in processing of plantain as primary business. Majority (88.2%) of the farmers interviewed sold their produce by themselves. About 10.3% indicated that their wives were in charge of

marketing of the plantain while 1.5% of the farmers indicated that their daughters and wives were in charge of marketing of plantains.

As indicated in Figure 2.8, majority (93%) of the farmers interviewed had regular customers or buyers. About 11.1% of the farmers interviewed observed damages of plantain when transporting to the local market. Plantain was mostly sold on the farm as shown in Figure 2.9.

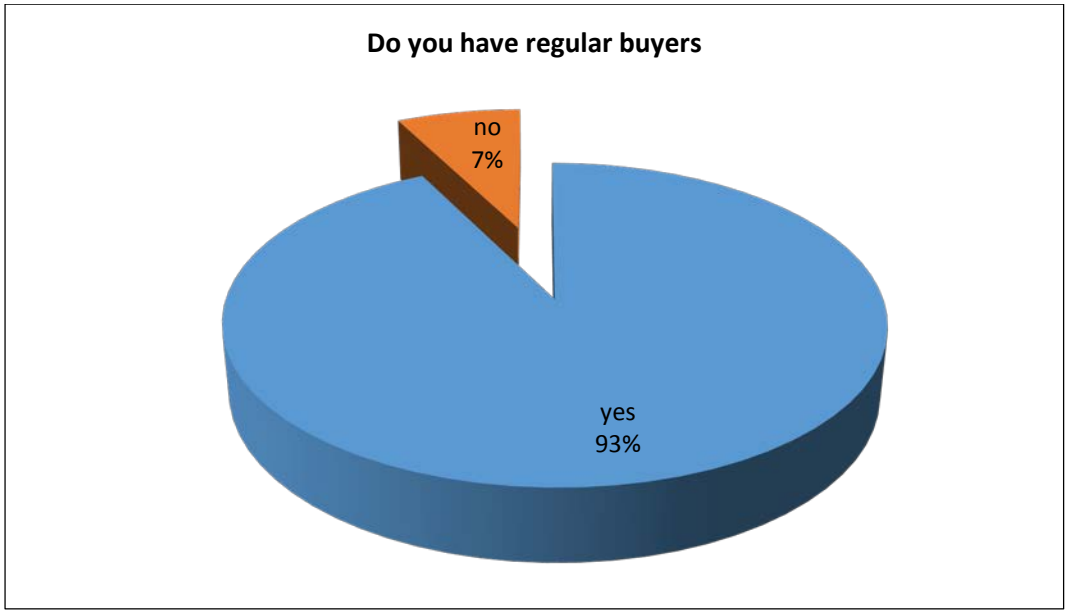


Figure 2.8 Clients of plantain farmers interviewed

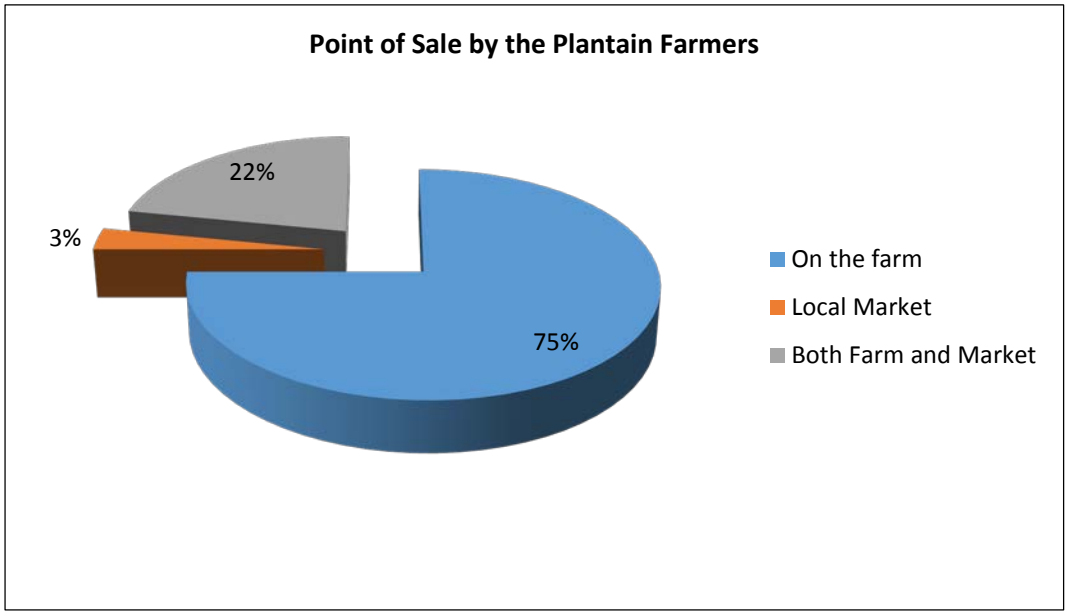


Figure 2.9 Sales Outlets of plantain farmers interviewed

By-Products of Plantain

Table 2.5 By-Products identified at the production level

By-Product	Utilization
Leaves	Cover/packaging for kenkey, left to decompose on the farm
Stems/Trunk	Cut into pieces and left on the farm to decompose and used as organic fertilizer
Peels	Animal Feed
Bunch	Cleaning of teeth, Cut into pieces and left on the farm to decompose and used as organic fertilizer For sponge/towel for bathing corpse

Source: Compilation by Authors, December 2016.

Table 2.6 SWOT Analysis at the Production Level

Strengths	**Weaknesses**
• Regular buyers • Experience in plantain farming • Possibility of staggering planting to get plantain all year round • Diversification of cultivation • Coping measures to control losses • Availability of labour	• Low records keeping • Low adoption of technologies • Less mechanization • Low production levels • Low bargaining power • Lack of knowledge on processing
Opportunities	**Threats**
• Processing opportunities • Availability of improved varieties • Up-Scaling opportunities • By-Products for composting • Linkages with new market opportunities	• Pests and rodent attack • Credit Sales • Buyers sometimes dictating prices • Price fluctuations • Theft on-farm

Source: Compilation by Authors, December 2016.

3.0 FINDINGS ON PLANTAIN PROCESSORS

3.1 Type of Business

All the processors interviewed were into processing of plantain chips. Figure 3.1 shows the flow charts for the plantain processed products in Ghana. Figure 3.2 shows sources of knowledge and skill acquired in plantain processing. Only 5.9% belonged to associations which were mainly for welfare purposes. Processing of plantains was at the small scale level and usually counted among Micro-Small scale enterprises (MSMEs) at the district level. Scale of production was limited to the level of market demand and availability of raw materials or seasonality of plantain which also affected price trends.

Processing of plantain chips is basically home-based business. Processing of plantain into chips was done in two main ways:

- peel, wash grate or slice into chip sizes, add salt and deep fry in hot oil, cool and package; and
- wash plantains in water, peel, grate/slice into chips, add salt and deep fry in hot oil, cool and package.

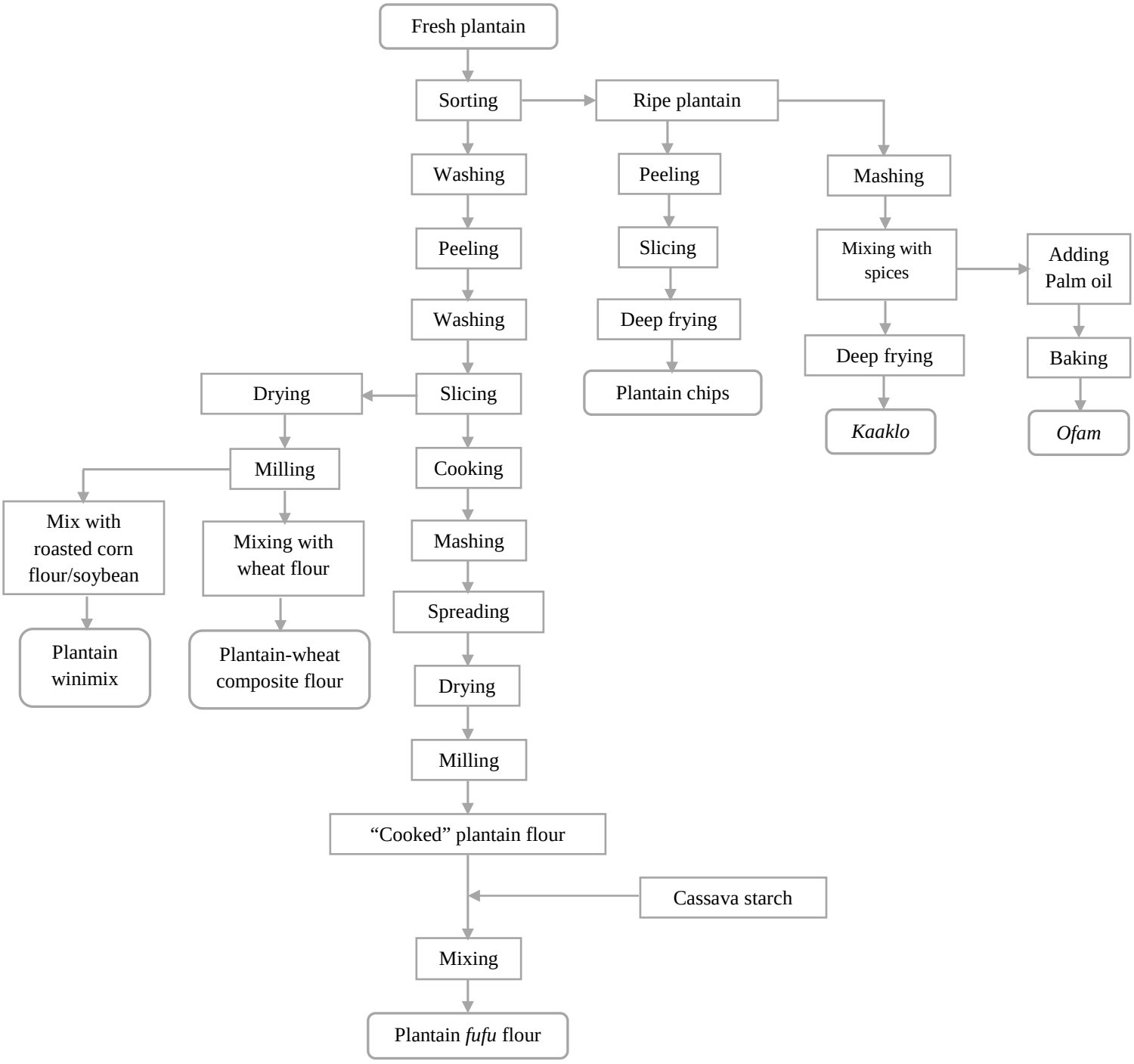


Figure 3.1 Flow Chart of Plantain Processed Products

Processors interviewed acquired their processing skills through apprenticeship, formal vocational education and informal learning from family members as indicated in Figure 3.2.

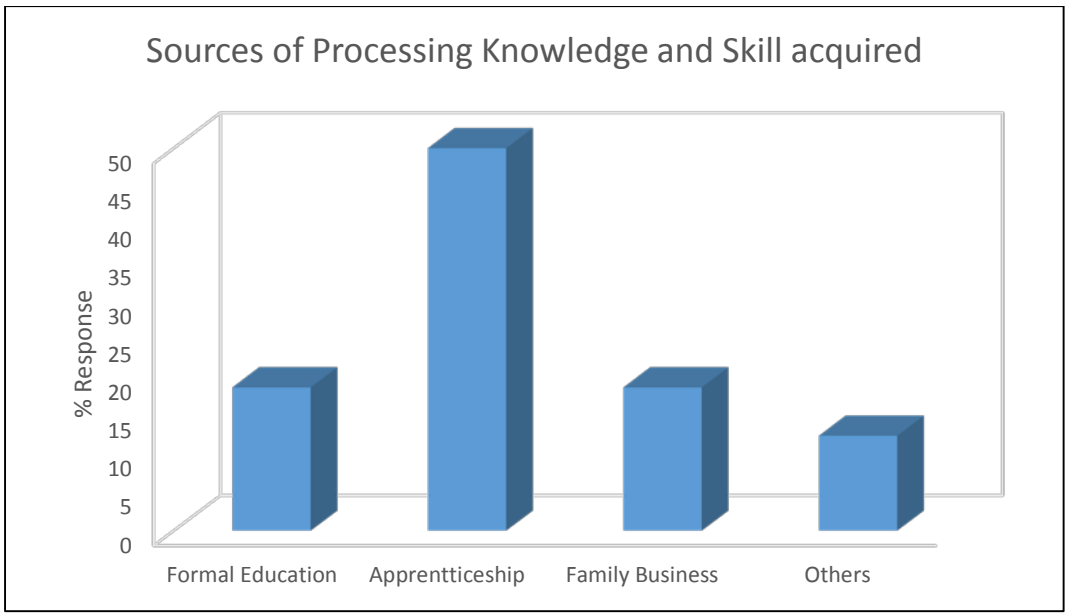


Figure 3.2 Sources of Knowledge and Skill of Plantain Processing

In addition to processors interviewed, there are processors of plantain fufu flours at the small-medium scale level but the processing capacities of individual processors are very low. Other research works have developed plantain starch as new value added products (Zakpaa et al 2010).

3.2 Preferred plantain Varieties for processing

Plantain processors interviewed had varietal preference for processing. Preferred plantain varieties for processing were *Apantu* and *Asiemienu* as indicated in Figure 3.3.

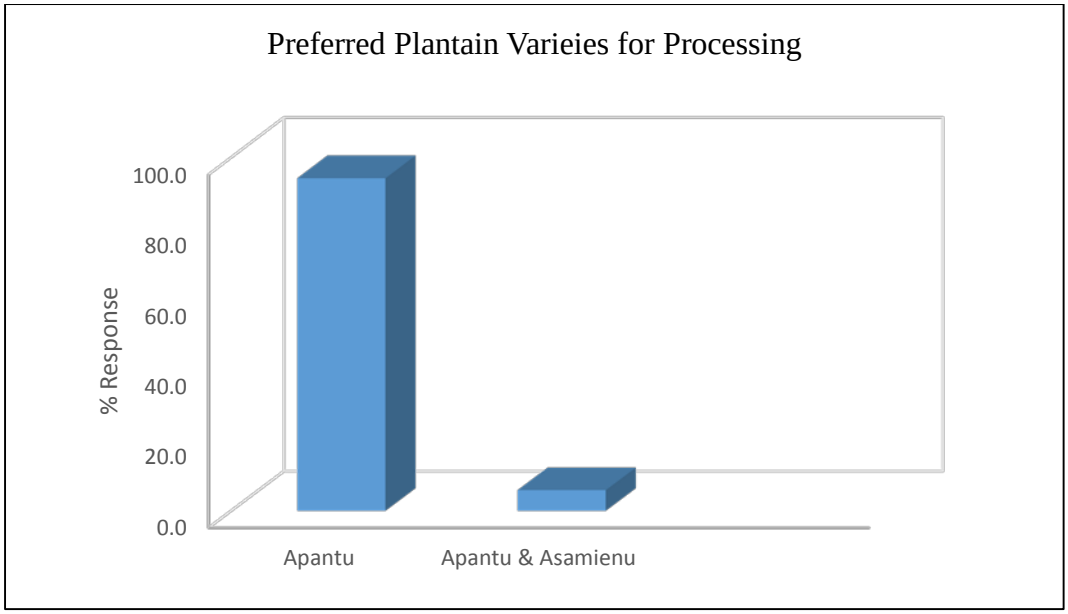


Figure 3.3 Varietal Preferences by Plantain Processors

The reasons for the choice of plantain varieties by plantain processors were as follows:

- Because of the size (big size, higher quantity)
- Gives good product
- Good taste
- It matures & ripens faster
- Acceptability by consumers

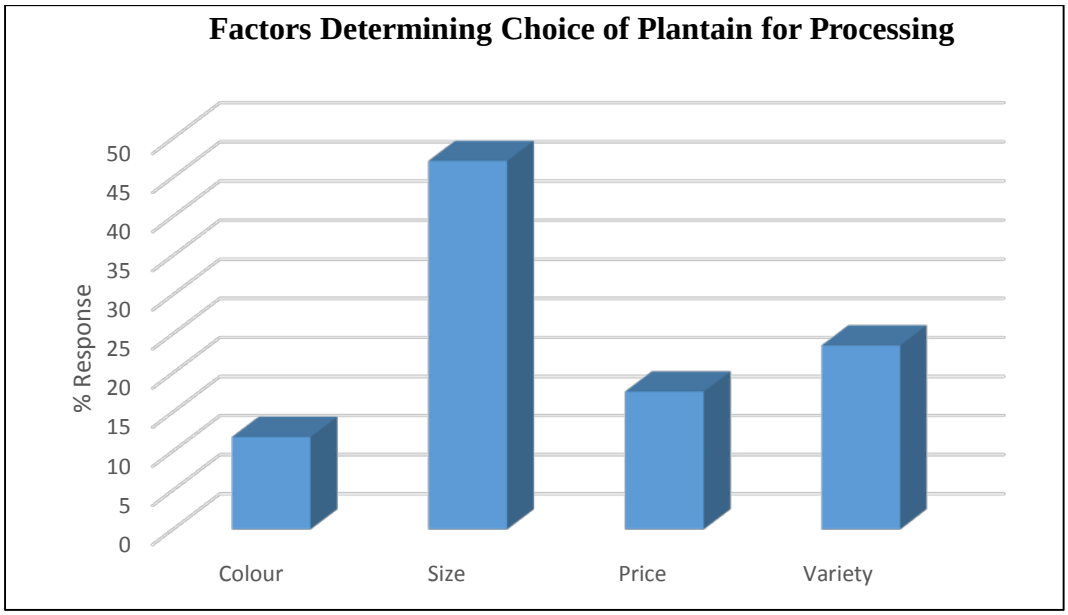


Figure 3.4 Factors determining choice of Plantain for processing

3.3 Sources of plantains for processing and storage Practices

Plantain for processing are sourced from the market by 81.2% of the respondents, farm gate (6.2%) and middlemen (12.5%). Purchased plantains for processing are transported by commercial vehicles (81.2%), Push Carts (12.5%) and using head-pans (6.2%). Processing Capacities ranged from 10 bunches up to 25 bunches of plantains per week per processor. About 87.5% of the processors interviewed stored purchased plantains in their homes before processing. Purchased plantains for processing were stored in the house for up to 5 days.

Storage practices at the processing level include the following:

- Cover with sack to facilitate ripening
- Put in a barrel to ripen
- Store in the kitchen
- Keep in a cool place and open place
- Store in sacks

About 41.2% of the processors interviewed observed some losses during storage. Losses at the processing stage were minimal and mainly caused by rotting of ripe plantains. Coping strategies to minimize losses during storage at the processing level included processing ripe ones first and limiting the amount purchased to market demands. In situations where excessive ripening occur, plantains were sold to *kelewele* sellers

By-Products at the Processing Level

By-products generated at the processing level were mainly peels. About 75kg of plantain peels were generated per week per processor. Majority (70.6%) of the processors interviewed sold plantain peels for animal feeding. About 11.8% of the respondents sell peels for use as raw materials in soap making while the remaining 17.6% disposed them off in the refuse dump. Waste water generated after washing peeled plantains or fresh plantains were disposed of as well.

3.1 SWOT Analysis at the Plantain Processing Level

Strengths	**Weaknesses**
• Regular buyers • Experience in plantain processing into chips • Availability of plantain throughout the year (but there are peak and lean periods) • Availability of labour	• Limited processing portfolio • Lack of knowledge on other processing products • Seasonality of plantain and associated fluctuations in prices • High cost of transportation • Lack of credit facilities

Opportunities	**Threats**
• Other Processing opportunities (instant *fufu flour, plantain flour for bakery products, tatale*) • Linkages with new market opportunities • Employment generating opportunities • Utilisation of waste or by-products	• Price fluctuations • Losses during storage

Source: Compilation by Authors, December 2016.

4. 0 FINDINGS ON PLANTAIN SELLERS

4.1 Plantain Seller Category and Sources of Supply

Three key categories of plantain sellers were identified in the surveyed areas. These include (i) Suppliers only, (ii) Retailers only, and (iii) Both Supplier and Retailers. Figure 4.1 shows the plantain seller categories indicating that majority (71.7%) of the respondents were retailers. Only about 4.9% belonged to an association.

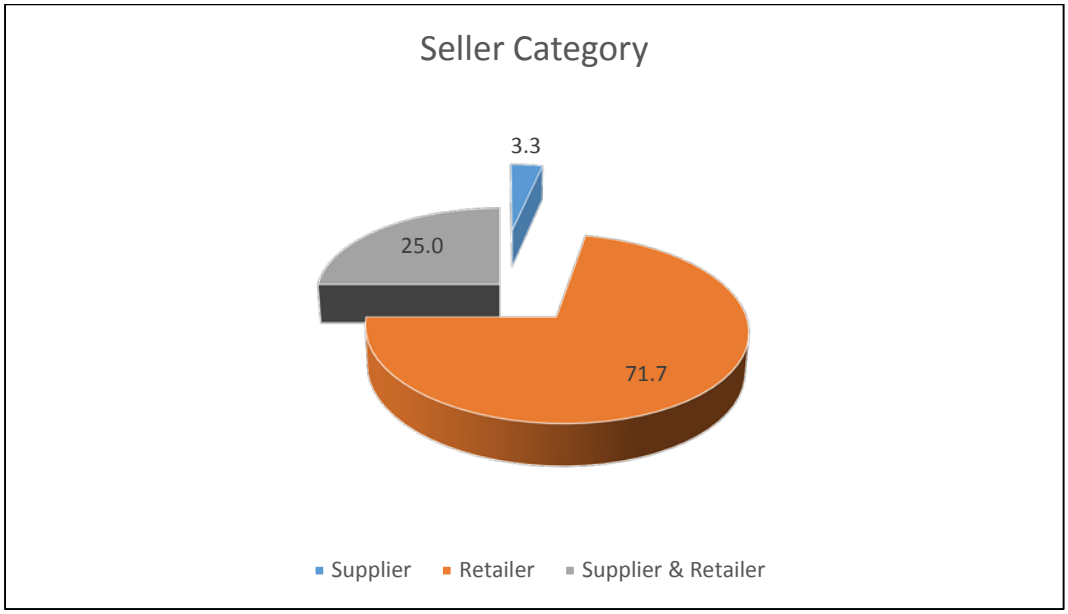


Figure 4.1 Seller Categories interviewed

Plantain Sellers interviewed sourced their plantains from the farm gate, market and middlemen/women constituting 65.1%, 23.8% and 11.1% respectively. Quantity of plantains sold per week ranged between 4-200 bunches depending on the type of trader (retailers sold low quantities)

4.2 Varieties Sold by Plantain Sellers Interviewed

The traders interviewed sold different varieties of plantains including *Apem, Apantu, Oniaba, Nyiretia* and *Asamianu* (Figure 4.2). The common combinations sold by the traders interviewed were *Apem* and *Apantu.* Selection of plantain from these 2 varieties were mainly based on maturity, appearance and size (Figure 4.3). Other factors influencing the choice of plantain varieties sold by traders were as follows:

- Availability,
- Customer preference,
- For profit,
- good quality, customer like it,
- Grow all varieties on the farm to satisfy wide range of customers,
- Market demand,
- There is market for *Apantu*
- To attract more customers.

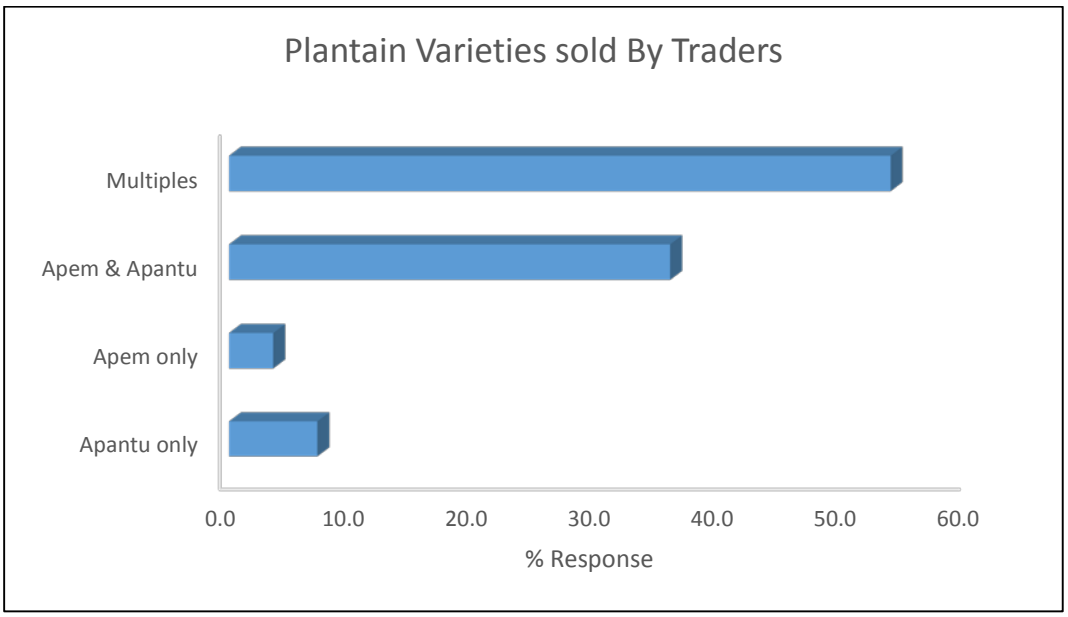


Figure 4.2 Plantain varieties sold by traders interviewed

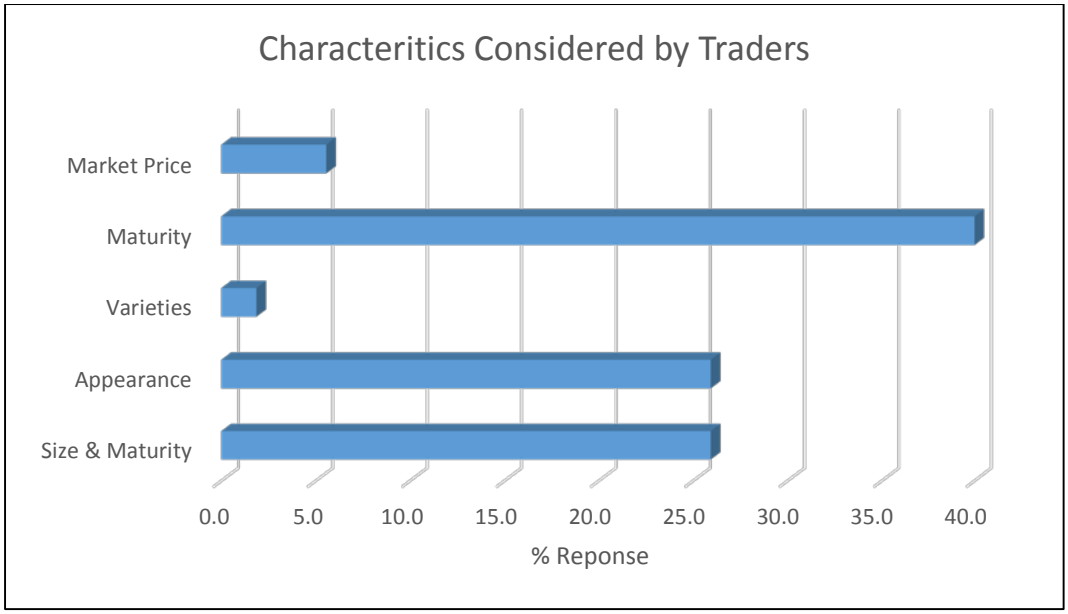


Figure 4.3 Characteristics by traders interviewed

4.3 Storage Practices by Plantain Sellers Interviewed and causes of Losses

Losses at the market/sellers level was estimated at 25kg (mini sack) to 10 baskets/about 30 bunches out of 200 bunches (spoilage also occur at the farm storage). This translates into approximately 15% loss.

Storage Practices

- At the market
- cool place
- corridor
- Home as long as possible
- In the house but away from sunlight
- keep in an open place
- Leave in open place
- Spread on the floor
- Store in the farm

Causes of loss include the following:

- Ripening
- Rot
- Wilting and darkening
- Mechanical damage and ripening
- Rotting and wilting
- Darkening and ripening
- Bruises during transporting from farm

Challenges facing Plantain Sellers

- Theft because here is no security in the market from
- Abundance and bumper harvest
- Buyers dictate the price
- High cost of transportation
- Difficulties in marketing, low sales, customers buy on credit
- Plantain ripens and it becomes a loss
- High levies from Assemblies, transportation, no market structure available
- low patronage during harvest, the mature ones ripe early
- low price and low sales during bumper harvest
- Lack of proper storage
- Carrying left over back to the village
- People bargain too much
- Reduce to clear and low sales
- Price fluctuation
- When trucks develops fault on their way and not getting people to buy produce

4.4 By-Products at the Trader/Market Level

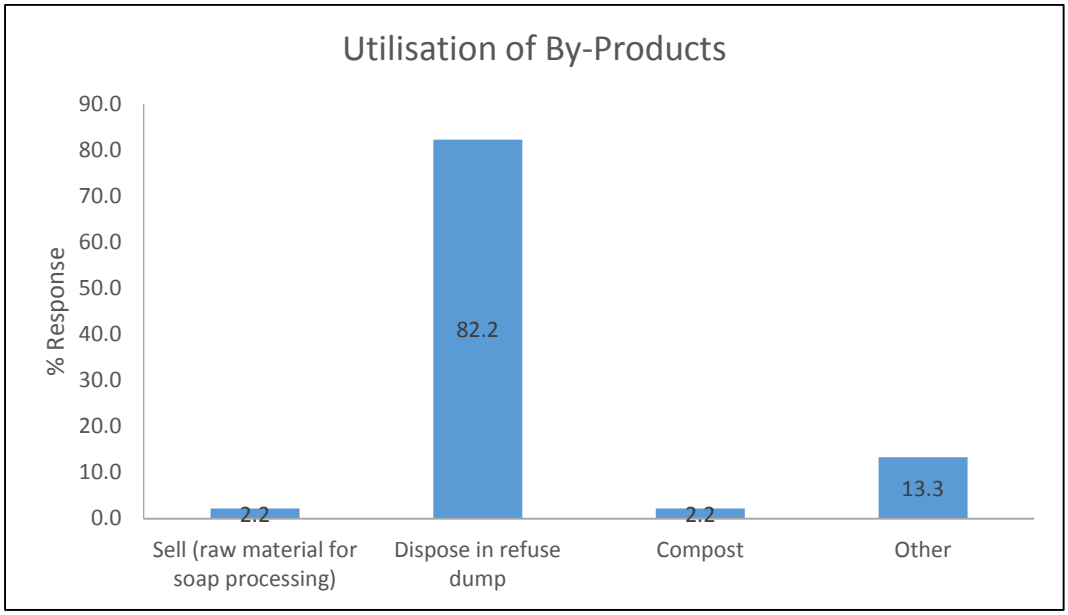


Figure 4.4 By-Products at the Trader/Market Level

4.1 SWOT Analysis at the Trader/Market Level

Strengths	**Weaknesses**
• Availability of Plantain throughout the year although there are peak and	• High Transportation Cost • Lack of storage structures/facilities

lean periods • Increasing demand for plantains • Preference for fresh Plantains and knowledge in good storage practices	• Seasonality of plantain and associated fluctuations in prices • low price and low sales during bumper harvest
Opportunities • Growing populations with associated increase in demand • New markets for value added plantain products • Utilisation of waste or by-products	**Threats** • Losses during storage • Harsh weather conditions facilitating ripening and rotting • Theft at the market • Break down of trucks during transportation

Source: Compilation by Authors, December 2016.

5.0 FINDINGS ON CATERING, RESTAURANT AND OTHER INSTITUTIONS

5.1 Type of Business engaged in by respondents

Majority (86.5%) of the respondents were involved in Canteen/Restaurant business (Figure 5.1). This category of respondents mainly used fresh green plantain to prepare *fufu* and *ampesi*. However, respondents who used plantain in the preparation of *fufu* constituted 97.4%.

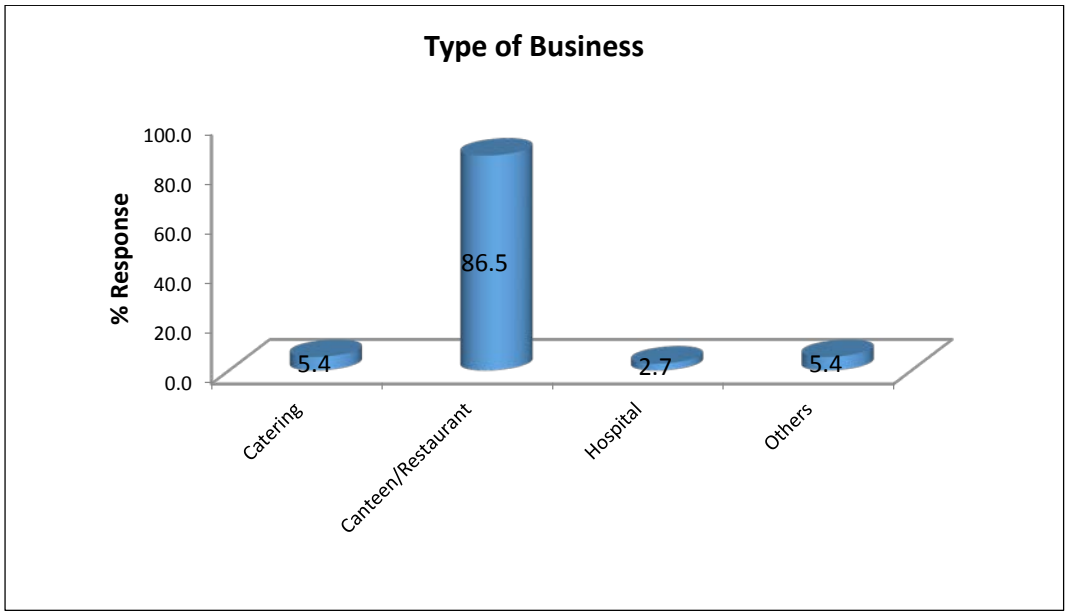


Figure 5.1 Type of Business engaged by respondents

5.2 Varietal preference by respondents and Sources of Plantain

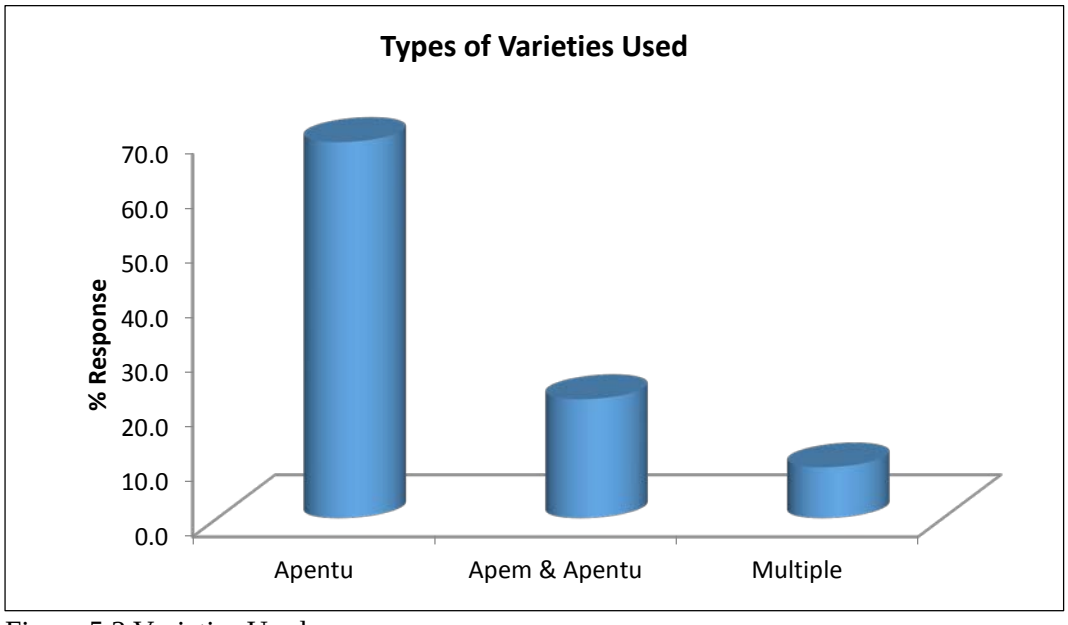


Figure 5.2 Varieties Used

As shown in Figure 5.2, the respondents mainly used *Apantu* and *Apem* in their line of business. That notwithstanding, they revealed that varietal preference was based mainly on color, shape/size and the type of food (whether *fufu* or *ampesi*) (Figure 5.3). According to them, *Apantu* has good pounding properties and is therefore preferred for use in *fufu* whereas *Apem* is mainly used in making *Ampesi* respectively.

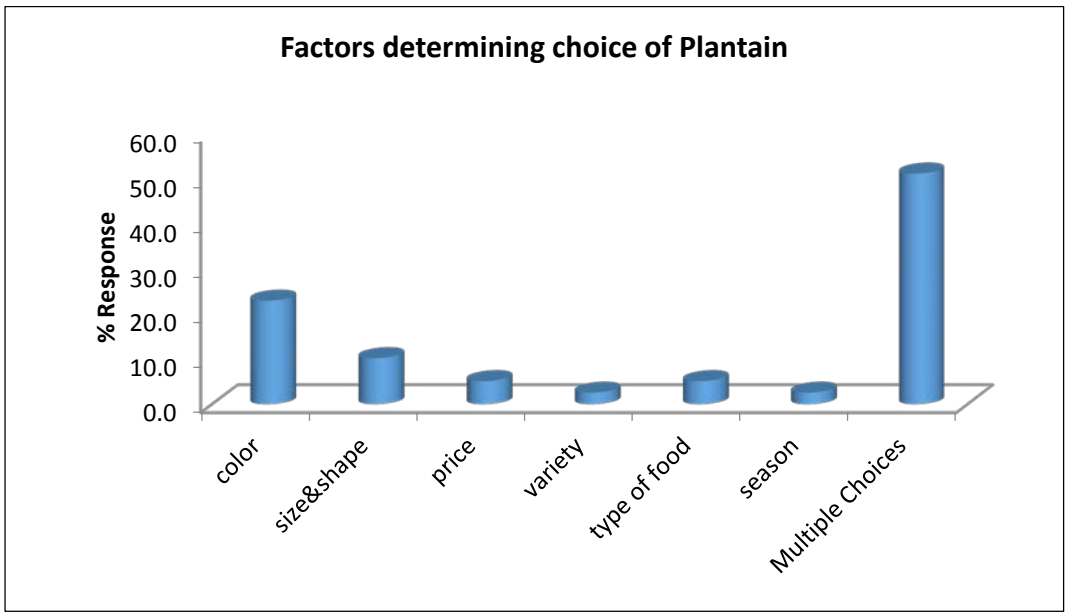


Figure 5.3 Factors determining choice of Plantain

On the average, the quantity of plantain purchased per week was 20 bunches per caterer. Majority (94.7%) of these caterers sourced plantain from the market while the remaining obtained theirs directly from farm gates. Nearly 95% of caterers who source fresh plantain from the market buy from retailers while the rest (5.3%) purchase directly from middlemen who supply in bulk.

The market price of plantain was found to be influenced by the season, as indicated by 91.9% of the respondents. This was followed by quality (5.4%) and variety (2.7%). The purchasing pattern, on the other hand, was mainly influenced by availability of plantain as reported by 68.4% of respondents. The remaining factors mentioned were pricing and market demand. These factors accounted, correspondingly, for 26.3% and 5% of the catering/restaurants interviewed.

Storage practices at the catering level

The survey revealed a number of strategies adopted by the respondents at the catering level to prevent spoilage and or ripening during storage of fresh green plantain. There storage practices varied widely and are listed below:

- Store in an airy place
- Store in a cool dark place
- Store in kitchen/canteen floor
- Store in water to prevent ripening
- keep in a place without heat

- Put in cool place
- Put in fridge
- Store on pallets in an open place

Waste from plantain

Largely, peels and bunches were the waste generated from plantain at this stage. Estimations of waste peels and bunch are shown in Table 7.2. Peels constitute approximately 35% of the total weight of a bunch of plantain with the fingers while the bunch without the plantain fingers constitutes approximately 11%.

6.0 FINDINGS ON CONSUMERS

6.1 Varieties of plantain preferred by consumers

Apem and *Apentu* were the most preferred plantain varieties by the consumers interviewed. As shown in Figure 6.1 about 44.6% of the consumers interviewed indicated that *Apem* and *Apentu* were the most preferred plantain varieties. Those preferring only *Apentu* constituted 24.8% while 6.9% preferred only *Apem.* About 24.8% of the consumers interviewed used all kinds of varieties (including *Apem, Apentu, Oniaba* and *Asiemianu*) and could not indicate any preferred choice.

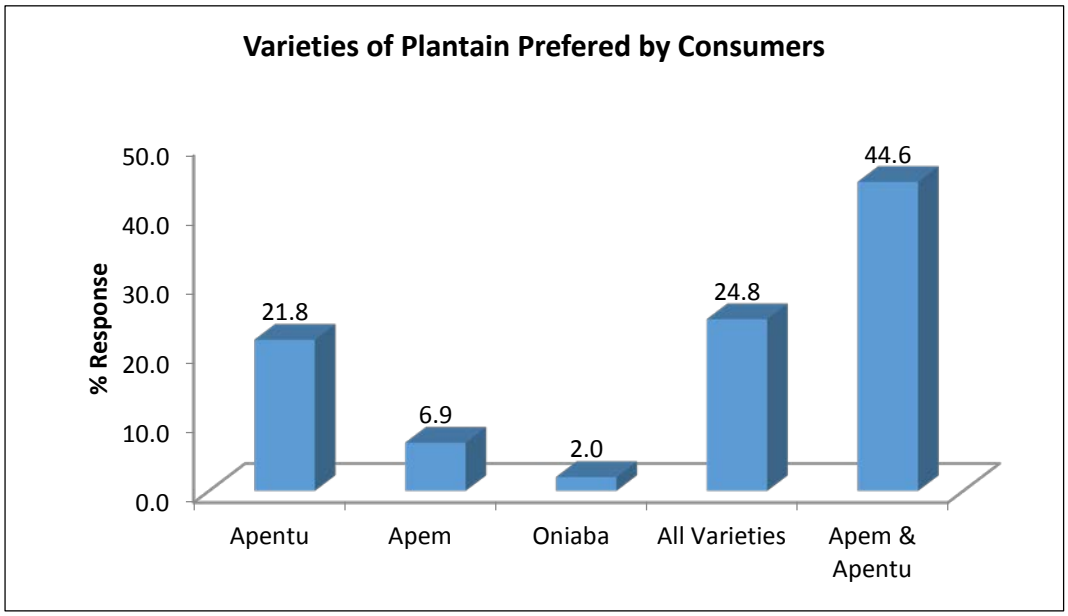


Figure 6.1 Plantain varieties preferred by consumers interviewed

As presented in Figure 6.2, factors determining the choice of plantain purchased by consumers were varied. However, the most common factor determining the choice of plantain purchased by consumers was the maturity which was also interpreted as size of the plantain.

Other factors determining the choice of plantain purchased by consumers interviewed were taste (probably attached to the type of variety) price, colour (depending on the usage could be ripe or fresh) and shape. About a third of the sample of consumers interviewed actually expressed combinations of factors (as indicated as multiples) determining the choice of plantain purchased.

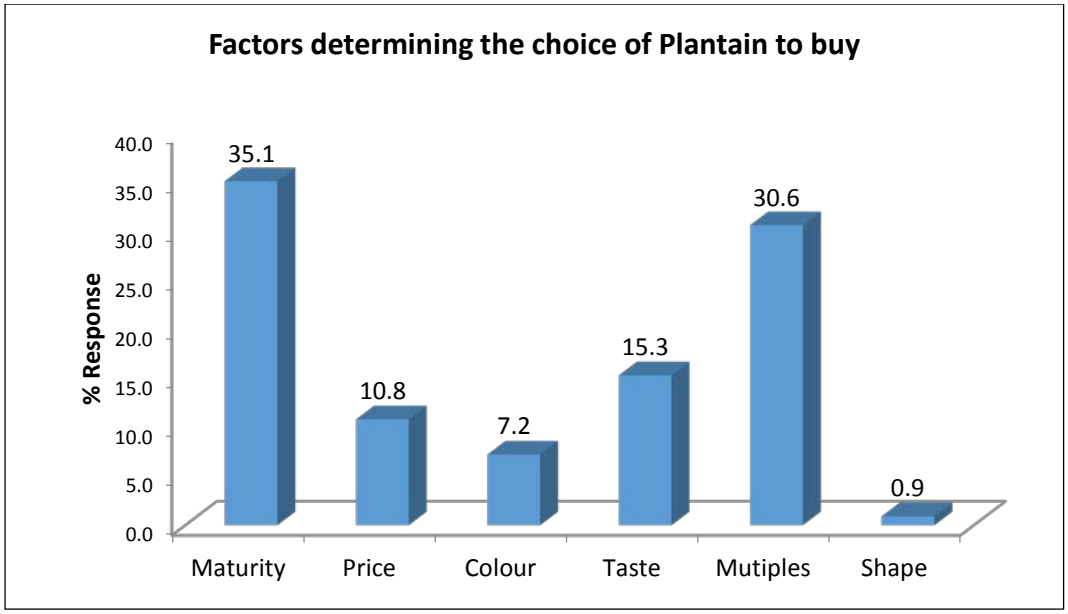


Figure 6.2 Factors determining choice of plantain bought by consumers interviewed

6.2 Frequency of Consumption of Plantain based foods by Respondents

Plantain products commonly consumed by respondents included *Ampesi* (boiled plantain), *Fufu* (boiled and pounded plantain with cassava), *Plantain Chips* (sliced and fried plantain) and roasted ripe plantain. Other plantain based foods mentioned by respondents were *eto, fried plantains, roasted plantains, tatale and kaklo* As shown in Figure 6.3, combination or multiples of plantain foods were consumed by the respondents.

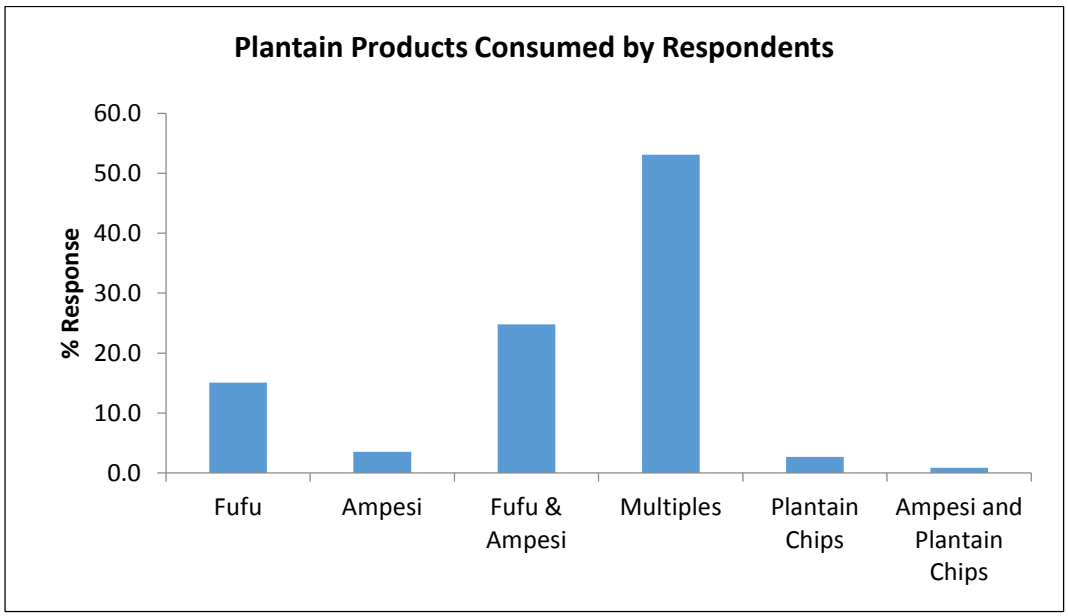


Figure 6.3 Plantain Foods Consumed by respondents

Plantain based foods were consumed more than twice a week by majority (76%) of the consumers as shown in Figure 6.4.

About 64% of the respondents indicated that frequency of consumption of plantain based foods varies depending on availability, price and need. The minimum quantity of plantain consumed per week was 4 fingers estimated at GHS 4.00 and maximum of 2 bunches per week per household estimated at GHS 20.00.

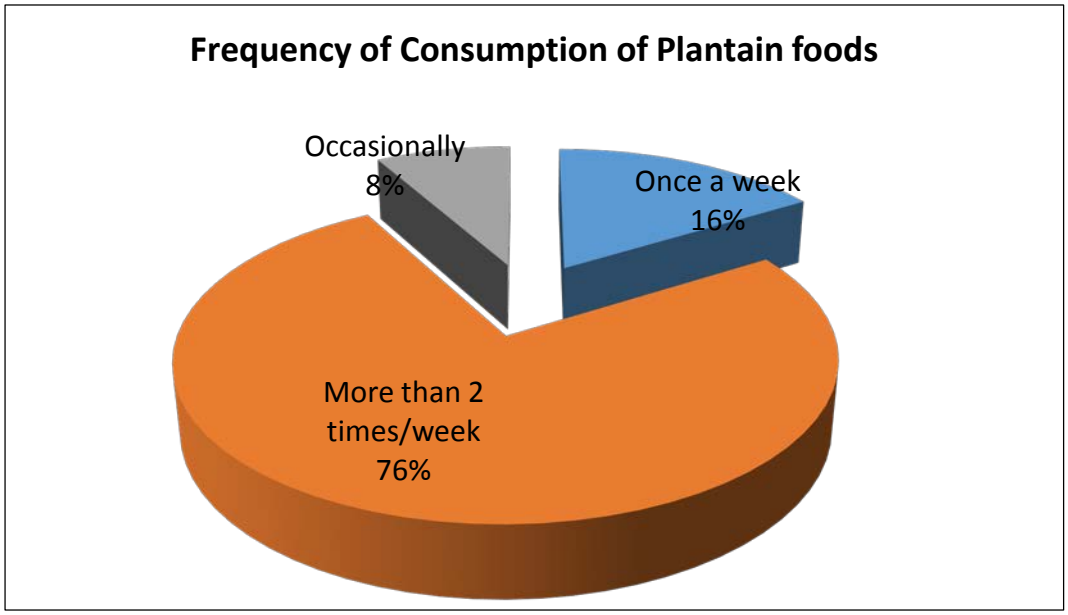


Figure 6.4 Frequency of consumption of plantain based foods by respondents

6.3 Storage Practices at the Household

Fresh plantains could be stored up to 3 months depending on the varieties. Storage practices at the household level mentioned by respondents included the following:

- Store in a cool place in the kitchen
- Keep in the refrigerator
- Arrange on the kitchen floor
- Clean, wash and keep in freezer
- In a basket
- In cool and airy place
- In the open
- Keep in water
- Keep in any place away from heat
- Keep in sacks to facilitate ripening
- Put them on sack in an open place
- Put them on the floor
- Store in water or fridge
- Store it in cupboard
- Under a table in the store room

Challenges during storage included ripening, rotting, mechanical injuries, rodents attack and diseases as depicted in Figure 6.5. About 71.2% of the respondents indicated that rotten plantains which could not be processed were disposed of into the refuse dump. About 15.4% of the respondents indicated that rotten plantains were used as animal feed.

Level of spoilage was estimated at 2 fingers per bunch or approximately less that 5%. To minimize waste respondents bought small quantities and ensured that good storage practices.

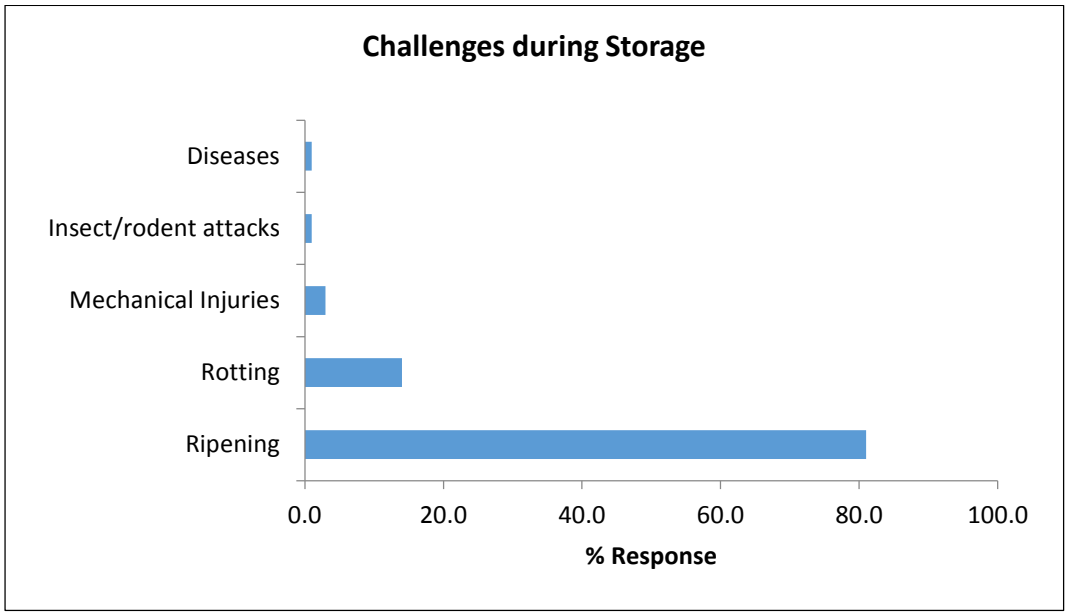


Figure 6.5 Challenges faced by respondents during storage of plantain

6.4 By-Products of Plantain at the Household Level

By-Products of Plantain observed at the household level include the following:

- Peels
- Reject (rotten/damaged fingers)
- Off-cuts
- bunches

About 61.6% of the respondents used plantain peels to feed animals. About 35.7% of the respondents disposed plantain peels off into the refuse dump. Less than 1% of the respondents sold plantain peels for soap making.

6.5 Processed Plantain Products

About 95.4% of the respondents patronized processed plantain products. Processed plantain products patronized by respondents included *roasted plantain, kakro, apiti, tatale plantain*

fufu flour and plantain flour, and *plantain chips*. As shown in Figure 6.6, the most common processed plantain products patronized by respondents were plantain chips and roasted ripe plantain.

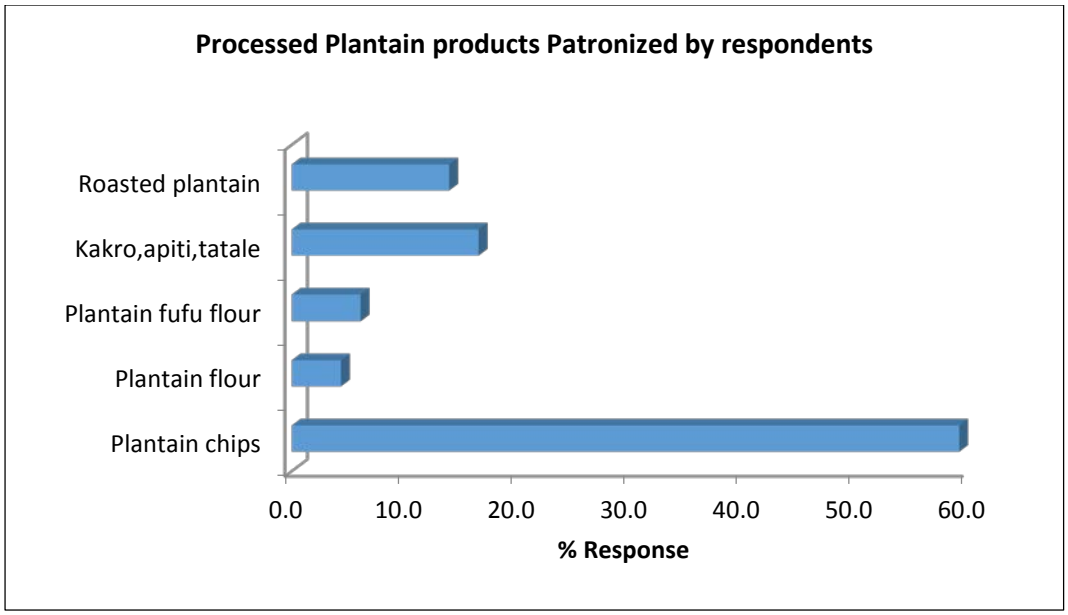


Figure 6.6 Processed plantain products patronized by respondents

About 94.8% of the respondents had observed an increase in the demand for plantain products especially for plantain chips. Observed increase in demand for high quality plantain flour was reported by 25.6% of the respondents. Apparently, high quality plantain flour was not popular in the surveyed areas suggesting the need to do more promotional activities on this fairly new product. Figure 6.7 shows the frequency of consumption of processed plantain products by respondents.

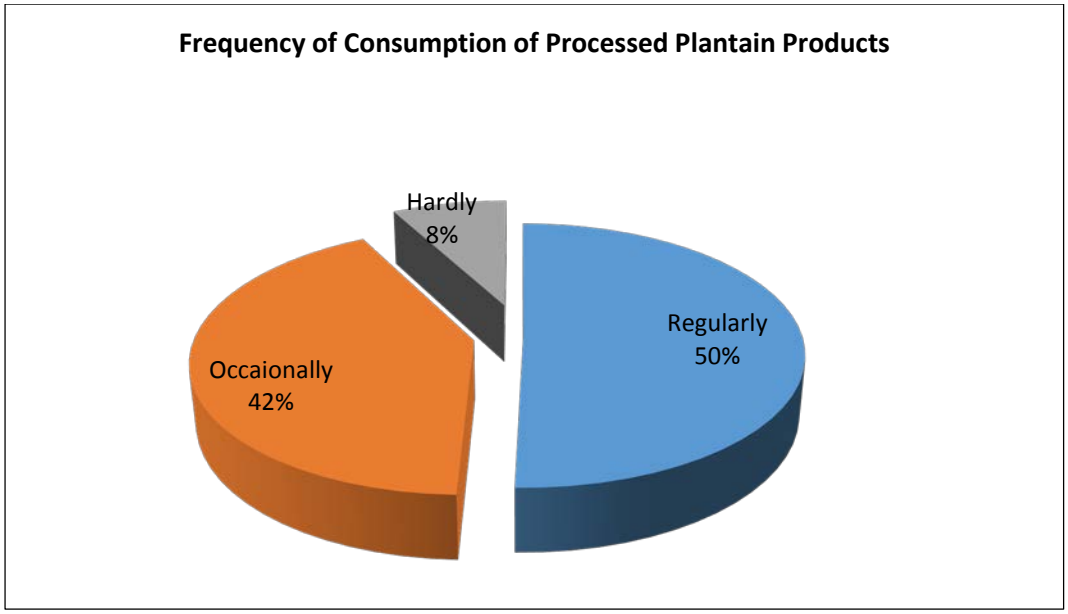


Figure 6.7 Frequency of Consumption of Processed plantain products by respondents

6.1 SWOT Analysis at the Consumption Level

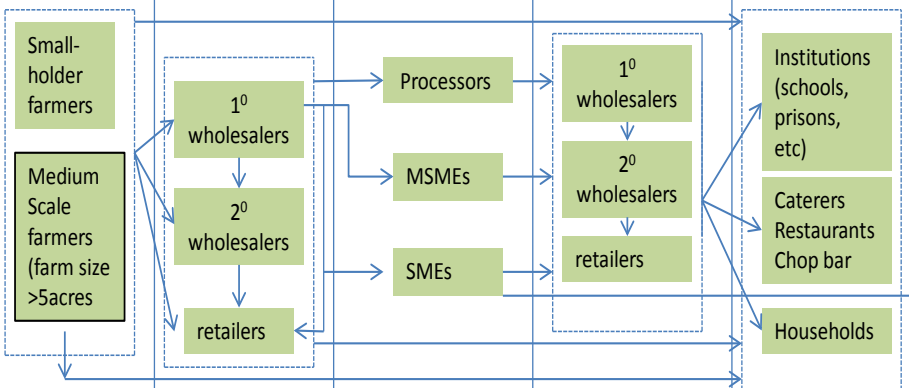
Strengths	**Weaknesses**
• Consumption of Plantain throughout the year • Increasing demand for processed plantain products • High population in the economic age group earning income/high purchasing power • Preference for fresh Plantains and good storage practices • Potential to contribute to strengthening national food security	• Lack of knowledge on high quality plantain flour • Seasonality of plantain and associated fluctuations in prices
Opportunities	**Threats**
• Increasing urban populations with Increasing demand for convenient foods • Increasing consumption of bakery products and possibility of replacing wheat flour with plantain flour • Opportunities to develop new processed products and promote existing ones • Opportunities for new markets • Utilisation of waste or by-products	• Losses during storage • Harsh weather conditions facilitating ripening and rotting • Growing quality concerns for Animal feed • Improper sorting of peels for animal feed

Source: Compilation by Authors, December 2016.

7.0 Plantain Value Chain

According to Getachew (2012), the agricultural sector defines value chain as an economic unit of analysis of a particular commodity or group of related commodities that encompasses a meaningful grouping of economic activities that are linked vertically by market relationships. Adopting the value chain concept by Miller and Jones (2010), the plantain value chain diagrammatically represented in Figure 7.1 shows the full range of activities and participants involved in moving agricultural products from input suppliers to farmers' fields, and ultimately, to consumers.

Figure 7.1a. Diagrammatic representation of the VC activities

Plantain	Production	Market	Processing	Distribution	Consumption	Export
Regulators	MoFA	MoFA	GSA, FDB, EPA	GSA, FDB	GSA, FDB	GSA, FDB, GEPC
Actors						
Preferred Varieties	All varieties	All varieties	*Apantu*		*Apantu* *Apem*	
Products	Fresh Plantain	Fresh Plantain	*Plantain Flour* *Plantain Chips* *Fried Plantain, kakro, tatale*	Plantain fufu flour Plantain chips	Fresh & processed plantain	*Fufu* flours
Service Providers	Harvesters, AEAs, NGOs, Financial Inst., GAIDA	Transporters, Financial Inst.	Peelers, Packaging companies, Financial Inst.,	Transporters, Financial Inst.	Institutional trainers	GEPC
Physical Losses	**Up to 20%**	**Up to 15%**	-	-	**Less than 5%**	-
By-Products	Leaves Stems Peels Trunk	Peels Trunk Rotten Plantain	Peels Trunk/bunch Rotten Plantains		Peels Trunk/bunch Rotten Plantains	

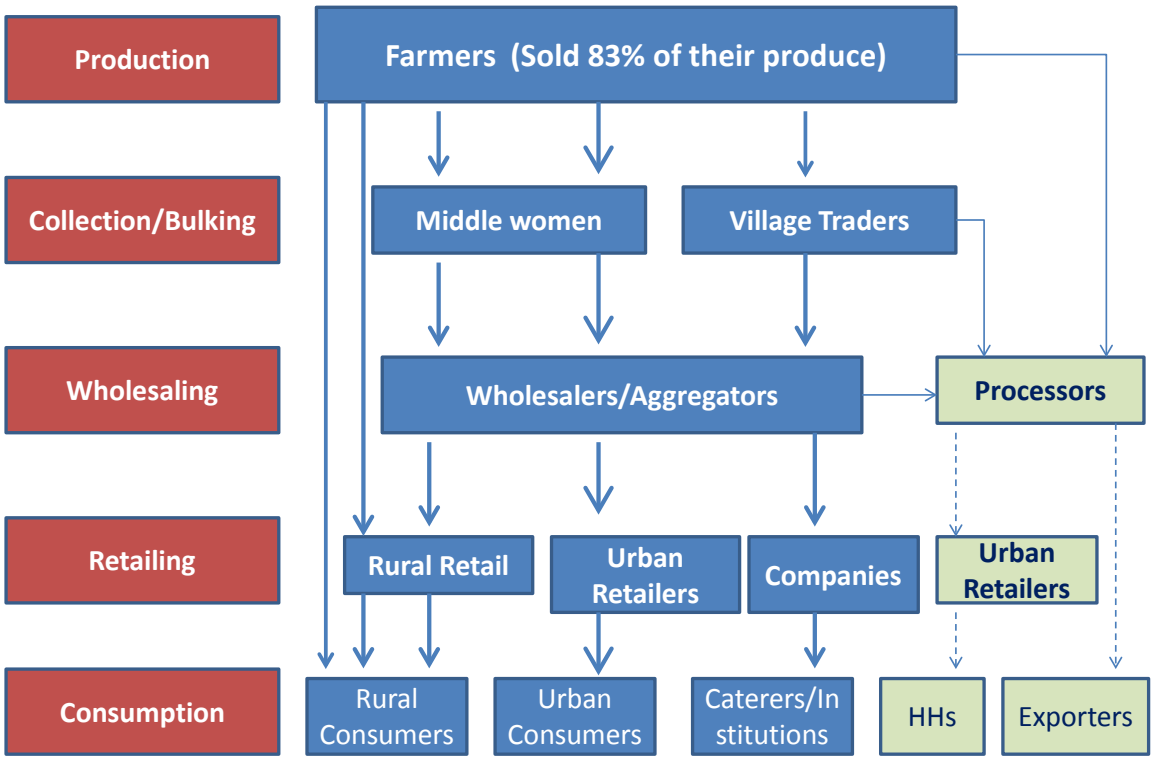
In addition to the identification of actors and their roles along the plantain value chain and tracing the flow of the commodity and value chain activities, this study also identifies the value addition opportunities that will help reduce post-harvest losses of plantains. Similar to the results obtained by Adeoye *et al*.,(2013) key actors/players identified in the plantain value chain are input suppliers, producers, traders (assemblers, wholesalers and retailers), processors, exporters and consumers. The processes in the Plantain Value Chain Map can be segmented further into three sectors namely:

• Upstream – Input supplies, service providers and production

• Midstream – Traders and Processors.

• Downstream - Retailers and Consumers

Figure 7.1b. Diagrammatic representation of the VC activities



7.1 Players and their Functions

Input Suppliers **-** These are responsible for procuring inputs from manufacturers or their representatives for retailing to producers. The inputs include agrochemicals such as herbicides, pesticides and fertilizers, planting materials and farm tools. Apart from input suppliers, there are service providers including financial institutions, rural service and extension provision by agricultural extension agents, NGOs and private sector players.

Producers/farmers **–** These are responsible for the production of plantain fruits. Majority of the plantain farmers operate on subsistence and small scale but there are significant percentage of medium scale plantain farmers as well as observed in Table 2.2. Majority of the plantain farmers sell their produce unprocessed at the farm gate. Farmers lack the capacity to produce although there are processing opportunities (see SWOT in table 2.6).

As evidenced Ouma (2010) plantain farmers have inadequate access to information on prices or minimal information flowing along the chain making them vulnerable to intermediaries. Some studies (Ekunwe and Ajayi 2010 and Kainga and Seiyabo 2012) have shown that plantain farmers in Nigeria do not have access to flexible and affordable credit facilities during the production cycle. Farmer's source their credit from friends and relatives.

Traders – There are different categories of traders in the plantain value chain. There are assemblers usually operating at the farm gate, middlemen who bulk plantain both at the farm gate and at the market place, wholesalers and retailers as well as traders of the processed product. Akinyemi *et al*. indicated that movement and distribution of plantains to major cities and other non-producing regions is usually performed by wholesale traders

Traders move around farms, collect the produce from farmers and transport it to the cities where they hand them over to wholesalers, who in turn pass the produce on to retailers or vendors for sale to consumers (ibid). (Akinyemi *et al*., 2010). Also according to Dzomeku *et al*., (2011) the marketing of plantains involves a large number of producers and a few wholesale traders who distribute plantains to consumers on a large scale. It was also noted by Dzomeku *et al*., (2011) that there are four main channels through which plantain reach consumers including (i) producer to wholesale traders to retail traders, (ii) producer to retail traders, (iii) wholesale traders to agri-industry and (iv) producer to agri-industry. Dzomeku *et al*., (2011) also indicated that many locations female market supervisors, often known locally as "market queens," manage every market and regulate the quantities and prices, and new entrants. Figure 7.1b shows the different categories of traders in the plantain value chain. .

Processors - Plantains are processed into different types of products such as plantain chips, plantain flour, and plantain fufu flour, traditional foods such as *tatale, kelewele, kakro and apiti.* Plantain chips (the most popular plantain product) are sold either by vendors on the street or by supermarkets (Ekunwe and Ajayi, 2000). Tchango *et al*., (1999) indicated the use of plantain flour for bakery products and baby foods. Plantain chips are primarily for local consumption with minimal export, while plantain flour has been marketed at the African diaspora (Dzomeku *et al*., 2011). The processor buys directly from the Producers and traders.

Caterers and Restaurants - Caterers and Restaurants services prepare plantain through a number of methods, including boiling, steaming, mashing, baking, drying, and pounding into *fufu* (a popular West African staple) made with boiled cassava, yams, or plantains that are pounded into a dough (FAO, 1990). Plantains are also prepared in combination with stew, vegetable sauces, fried kidney beans, roasted meat, or other dishes in various food joints and restaurants (Honfo *et al*., 2011). Also plantains are also spiced with chili powder, fried with palm oil, and served as a snack in restaurants (Yomeni *et al*., 2004).

Consumers –These are the final actors on the plantain value chain. Boiled or fried plantains and plantain *fufu* are preferred by consumers either as lunch or supper whiles plantain chips are mostly eaten as an afternoon snack (Honfo *et al*., 2011). According to Dury *et al*., (2002) consumers will prefer plantain to other staple foods such as cocoyam, maize and rice in a market where these food stuffs have the same price levels.

Tables 7.1 Biomass Percentages

No.	Plantain part	Percentage waste	Present usage	New businesses
1	Peels 	35%	Animal Feed Soap making Refuse dump/animal feed on, composting	Peels for soap Animal feed Pelleting for animal feed Peels for mushroom cultivation
2	Stalks (bunches) 	11%	Cleaning of teeth decomposing	
3	Immature fruits	-	decomposing	Animal feed
4	Over-ripe fruits	4%	Processed into traditional foods such as tatale,	Developing new processed products

			kelewele, kakro, apiti,	Bakery products
5	Rotten fruits	4%	Disposed off	Starch
6	Leaves 	>90%	Kenkey covering decomposting	
7	Stem 		Cleaning of teeth Decomposting Processed into ropes	

Tables 7.2 Percentages Biomass calculations

Parameter	*Apantu*	% of bunch of *Apantu*	*Apem*	% of bunch of *Apem*	Average % Biomass	Biomass from 2015 production (000MT)
Weight of bunch (es)	14 kg		15 kg			3958.1
Number of fingers	33		85			
Weight of bunch (without plantain fingers)	1.8 kg	13%	1.5 kg	10%	11%	435.4
Weight of peels	4.3 kg	31%	6.0 kg	40%	35%	1385.3
Weight of fingers	8.1 kg	58%	7.7 kg	51%	55%	2137.4

Source: Compilation by Authors, December 2016.

Tables 7.3 VC Percentages waste

No.	VC Activity	Percentage Waste	Percentage Utilization of waste	Others
1	Production	Up to 20%	Up to 20%	
2	Harvesting		-	
3	Bulking		-	
4	Transporting	Up to 15%	Up to 5%	
5	Retailing			
6	Processing	insignificant	-	
7	Consumption	Less than 5%	-	

Source: Compilation by Authors, December 2016.

Tables 7.4 Gender roles (men, women and youth) at VC levels

No.	VC Activity	Role	Percentage involvement
1	Production	Men, women and youth	Men (36.1%) and Women (63.9%) interviewed About 15% youth
2	Harvesting	Women, Men and Youth	Largely by women
3	Bulking	Women, Men and Youth	Largely by women and youth
4	Retailing	Women	100% women
5	Transporting	Women, Men and Youth	Largely by women and Youth
6	Processing	Women	100% Women for Plantain Chips. Men involved in processing plantain Flour
7	Consumption	Men, women, youth and children	Plantains consumed by all but plantain based foods basically prepared by women

NB: (Youth = less than 35years)

8.0 CONCLUSION AND RECOMMENDATIONS

8.1 Conclusion

This study identified the actors and their roles along the plantain value chain and value addition opportunities that will help reduce post-harvest losses of plantains. The study estimated post-harvest losses of up to 20% at the production and market levels and 15% at the consumption level. The study found that plantains are traded mostly unprocessed form. A similar result was found by Adeoye *et al* (2013) in Nigeria. About 83% of the plantains produced by the farmers were sold fresh. Although, the farmers interviewed were highly influenced by the market dictates they also considered household food security demands. Horizontal flow of the plantain commodity was prominent among actors with limited value addition at the processing level. The cross cutting constraints among the actors were inadequate credit accessibility, high transportation cost, limited processing capacities, seasonality of plantains and fluctuation in prices, marketing challenges, losses during storage and transportation especially with frequent vehicle breakdowns among others.

8.2 Recommendations

The study recommends the following:

- Intervention in the area of linking actors in the value chain to prospective markets;
- Take advantage of improved varieties and possibility of staggering planting to get plantain all year round;
- Research to improve on the existing coping measures to control losses at all the stages of the plantain value chain;
- Promote utilisation of new processed products and increase the capacity of processors;
- Continuous research in the possibility of replacing wholly or partially wheat flour with Plantain flours; and
- Develop new products from by-products to create value opportunities from waste generated along the plantain value chain.

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