PLANTAIN

Post-harvest Operations

INPhO - Post-harvest Compendium

Food and Agriculture Organization
of the United Nations

PLANTAIN: Post-harvest Operations

Organisation: Centre de Recherches Regionales sur Bananiers et Plantains, Cameroon (CRBP)
Author: J. Tchango Tchango, A.Bikoï, R. Achard, J.V. Escalant & J.A. Ngalani
Edited by AGSI/FAO: Danilo Mejia (Technical), Beverly Lewis (Language&Style)
Last reviewed: 14/10/1999

Contents

1. Introduction

Plantains and other cooking bananas, staple foods grown throughout the tropics, constitute a major source of carbohydrates for millions of people in Africa, the Caribbean, Latin America, Asia and the Pacific. Due to the perishable nature of the fruits, the rate of plantain post-harvest losses varies from one country to another according to the organisation of market chains and modes of consumption. In many producing countries, there are no data on post-harvest losses. The assessment of these post-harvest losses is rather complex because green mature plantains are consumed as well as overripe fruits. However, some factors are likely to

depreciate quality and provoke post-harvest losses. These include poor transportation and distribution facilities in the production areas, harvest at maturity close to fruit ripening, and poor storage conditions.
In Cameroon, the most evident post-harvest losses are registered at the producer level in enclave sites during the rainy season (N'da Adopo, 1993). These losses should be less than 35 percentage) in developing countries as previously estimated by FAO (1987).
In plantain production, labour distribution according to sex varies with producer traditions and the economic role of production. In Cameroon, men and boys over 12 years olds are generally in charge of land clearing, land preparation and planting. Women and girls over 15 years old step in go to the planting site and to monitor crop growth. Men and women both perform the transport and sale of products.

1.1 Economic and social impact

Plantains (AAB) as well as other cooking bananas (AAB and ABB), East Africa cooking bananas, beer bananas (AAA) and dessert banana (AAA) belong to the Musa genus. Figure 1 shows great diversity among plantains and cooking bananas.

Figure 1, Bunches of plantains and cooking bananas from the germplasm collection of CRBP in Njombé, Cameroon (Photo R. Achard)

Bananas and plantains are grown in more than 120 countries, in backyards or in mixed cropping systems by smallholders, and occasionally in monoculture (INIBAP, 1992). The total production is about 64 million tons with 23 percentage of AAB plantains, 16.5 percentage of cooking bananas, and 18 percentage of highland cooking bananas and beer bananas. The most prevalent combination of mixed cropping systems is cultivating plantains with coffee and cocoa. In Latin America for example (Colombia, Costa Rica, Venezuela), mixed cropping with coffee is common, but association with cocoa and pure stand of plantains are also found (Costa Rica and Panama). Table 1 presents some data on the production and the consumption of plantains and other cooking bananas in some producing countries.

Table 1 : Main producing and consuming countries of plantains and other cooking bananas

Countries	Yearly Production (x 1,000 tons)	Consumption (kg/person/year)	Plantain Calories Consumption (Calories/person/day)
Africa	600	67	111
Burundi*	1000	81	195
Cameroon	1000	81	194
Côte d'Ivoire	1530	49	112
Democratic Rep.of	1800	-	-
Congo	6700	150	348
Nigeria	2150	91	222
Uganda*	1350	-	-
Rwanda*	2463	82	197
Tanzania	960	-	-
Latin America	600	70	135
Colombia	580	-	-
Ecuador	105	-	-
Venezuela	1150	66	115
Peru	-	65	137
Bolivia			
Asia			
Philippines			
Sri Lanka			

** These countries produce mainly cooking and beer bananas.*
Sources : FAO (1989), United Nations (1991), Ganry (1990) and Lescot (1993).

According to Treche (1997), 69.4 percentage of plantains and other cooking bananas are used for human consumption while 8.0 percentage are used for animal feed. Post-harvest losses and transformed quantities in the world are 11.5 percentage and 11 percentage, respectively. In most cases plantains are locally consumed. Plantain also shows great adaptation to urban consumption and exportation to specific markets. This will vary from one country to another because of prevailing eating habits:

- Ripe or unripe plantain pulp cooked in water or vapour;
- Pastry from unripe plantain cooked in water and pounded in a mortar;
- Elastic pastry prepared from plantain flour and boiling water;
- Ripe or unripe plantain pulp roasted on charcoal fire;
- Unripe plantain pulp cooked with water, meat or fish, palm oil, salt and various spices;
- Slices of unripe or ripe plantain pulp fried in palm oil or other vegetable oils.

The available food energy (AFE) from plantains and other cooking bananas in some producing countries is shown in Table 2 (Treche, 1997).

Table 2 : Available food energy (AFE) from plantain and other cooking bananas in selected producing countries

Countries	AFE from plantains and other cooking bananas (Kcal/inhabitant/day)
Uganda	436
Gabon	432
Rwanda	422
Côte d'Ivoire	189
Cameroon	173
Ghana	172
Colombia	169
Dominican Republic	142
Guinea	140
Ecuador	119

1.2 Primary product

Boiled plantain

The fingers of ripe plantain or unripe plantain are peeled and cooked in boiling water or in vapour for 20 to 50 minutes depending on the cultivar and ripening stage of the fruit. Plantains boiled in this way are consumed with various sauces or other accompanying dishes. This mode of cooking and eating is quite common in most plantain producing countries in Africa.

Green mature fruits after peeling can be cooked in water mixed with palm oil, goat or cow meat, salt and diverse spices (*condre* in Cameroon). It is a classical dish for the people of West Cameroon during weddings, funerals and other traditional ceremonies. The pulp of unripe plantains cut into pieces can also be cooked with water, salt, palm or groundnut oil, groundnut paste, tomatoes and spices, fresh or smoked fish or meat. This makes a porridge or one-course meal.

Plantain pastry

Unripe plantain pulp after cooking in water or vapour is pounded in a wooden mortar to be transformed into a homogenous flexible pastry. The addition of a few pieces of cooked cassava can be needed to improve the elasticity of the pastry. This food called "*ntuba*" in Cameroon (Figure 7), "*foufou*" in Côte d'Ivoire, "*fufu*" in Nigeria and Ghana is always eaten with a sauce which is somewhat rich in proteins. It is a staple food in certain regions of these countries.

Figure 7, Plantain pastry (ntuba) prepared in Cameroon from the pulp of plantain boiled and pounded (photo S. Morelle)

Plantain Pastry lined with green leafy vegetables

Plantain fingers, generally of the horn or false horn type, are cooked in water with leafy vegetables (pumpkin leaves, amaranth leaves, etc.). After cooking, the plantains are peeled and pounded hot in a mortar. Vegetables, which were before hand washed in cold water and drained by hands are then added to the pastry as well as salt, pepper and unrefined palm oil. All of this is well mixed and served for eating.

Plantain pastry mixed with beans

The preparation is the similar to the preceding recipe, except cooked kidney beans are substituted for vegetables. The people in the West Cameroon prepare this recipe.

Roasted Plantains

The entire pulps of unripe or half-ripe plantains are roasted on heated charcoal. About fifteen minutes is enough to prepare simultaneously 2 to 4 fingers of plantain depending on the customers. Women on the roadside generally sell this plantain which is consumed warm with other delicacies (roasted plums, avocado, roasted fish, meat kebab). The cooking and selling of roasted plantain constitutes a major commercial activity for some women in Cameroon, Côte d'Ivoire and other plantain producing countries.

Fried plantains

Ripe or unripe plantain are peeled and cut into slices and fried in palm oil or other vegetable oil for 4 to 5 minutes at 160-180_C. Roasted fish, chicken or meat kebab are sometimes served. Fried ripe plantain or *aloko* in Côte d'Ivoire, *red-red* in Ghana and *dodo* in Nigeria is a meal well cherished by children and in restaurant. Fruits of certain cooking bananas (Topala, Pelipita, Popoulou, Kalapua N_2, etc) also produce good quality fried plantains.

Plantain fritters

The pulp of over ripe plantains are pounded and mixed with a small quantity of maize or other local cereal flour (about 1/4 of pulp weight) and salt to form a homogeneous pastry. The fritters obtained by deep frying of small pastry balls in palm oil (160-180_C for 4 to 5 minutes) are eaten hot or warm alone or with other dishes (sauce, spices, fried beans, etc). Over ripe fruits of dessert or cooking bananas can also be used.

Plantain Chips

Plantain chips are the most popular plantain products in Nigeria (Onyejegbu and Olorunda, 1995). They are prepared by frying round slices of unripened or slightly ripened plantain pulp in vegetable oil (Figure 8). Best quality plantain chips have been obtained in Cameroon by frying round slices of pulp (2 mm thick) in refined palm oil between 160 and 170_C for 2 to 3 minutes (Lemaire et al, 1997). These generally absorb less frying oil than chips from cooking banana and dessert banana. The antioxydising treatment (soaking in citric acid solution) which is indispensable to inhibit the action of polyphenoloxydase responsible for the browning of the pulp of dessert banana before frying is not necessary when making chips from plantains and certain cooking bananas (Lemaire et al, 1997). The plantain chips prepared in this way and packed in plastic sachets or in hermetic aluminium sachets (Figure 10) can stay crispy and conserve all their quality for more than 4 months at room temperature and away from light. They generally contain less than 35 percentage of fats and between 1 to 3 percentage residual humidity.

The production and marketing of plantain chips in Africa (Cameroon, Nigeria, Ghana, and Côte d'Ivoire) is principally a feminine activity, which has greatly developed these past years. They are generally eaten as snack food. Industries producing banana and plantain chips have

equally been developed in Cameroon and Colombia to give more value to this perishable food product. These industrial or semi-industrial units use various equipment making it possible to mechanise certain activities in the production chain. The "robot-coupe" (models R 502, R 602, or R 602 VV) used for the rapid slicing of banana or plantain pulp into round sizes of uniform thickness is an example (Figure 9). In industry, frying can be done using continues or discontinues electric or gas deep fryers, whereas vacuum packaging with appropriate apparatus is welcome.

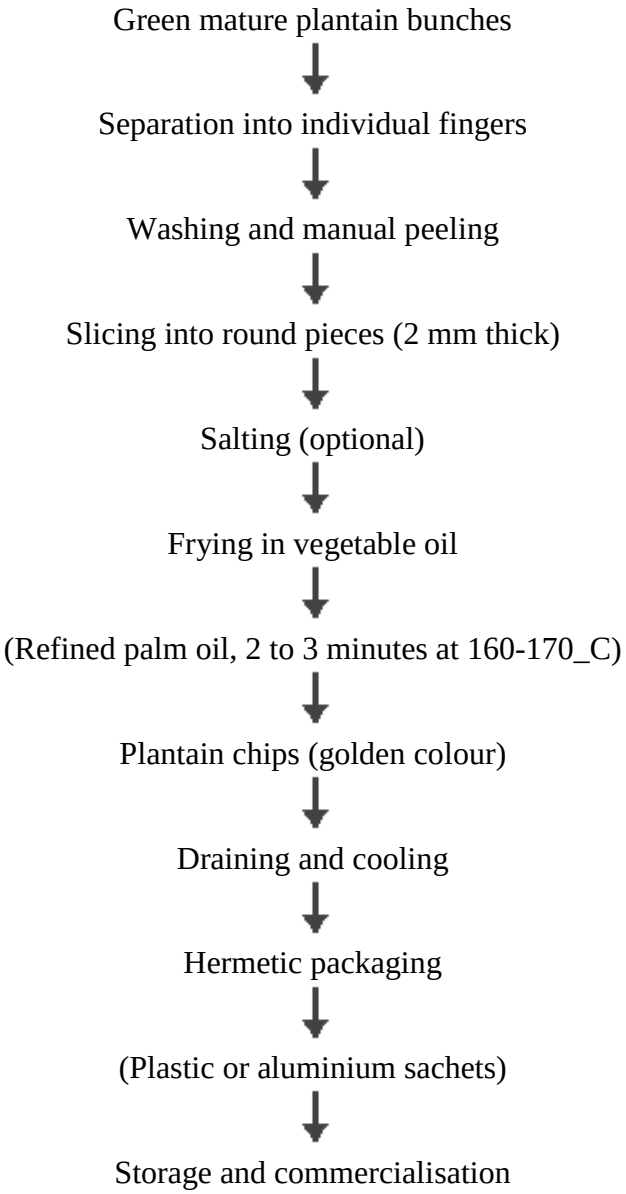
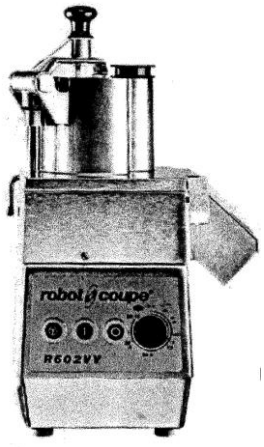


Figure 8: Flow chart for the preparation of plantain chips (Lemaire et al., 1997)



,

Figure 9: A "robot-coupe" used for rapid sliing of banana and plantain pulp into round sizes of uniform thickness (reproduced from the catalogue of ROBOT-COUPE S.N.C., France).

Figure 10, Traditional and industrial packaging of plantain chips produced in Cameroon (photo. J. Tchango Tchango)

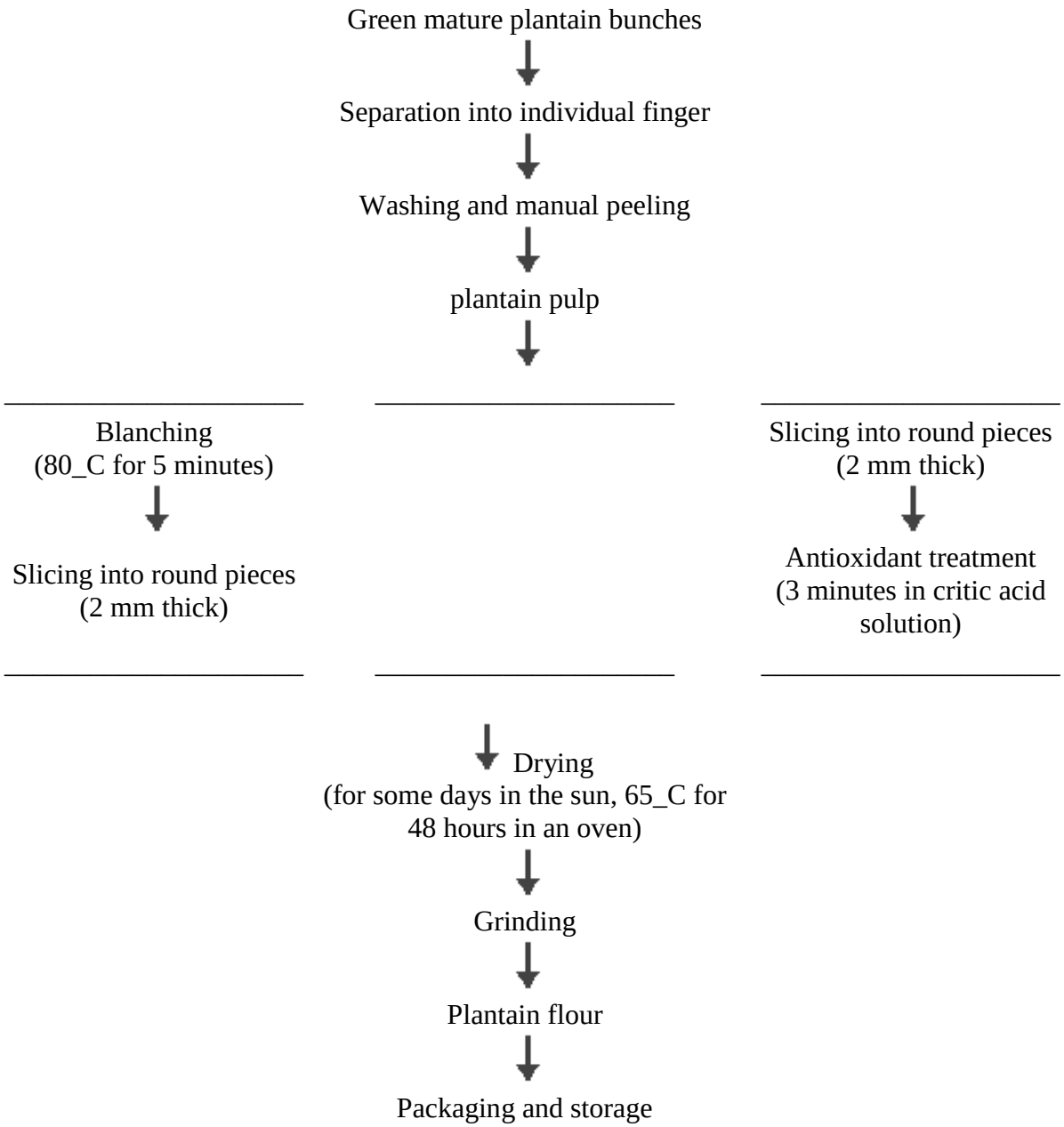


Figure 11: Plantain flour production flow chart (Ngalani, 1989)

Unripe plantain is traditionally processed into flour in Nigeria (Ukhum and Ukpebor, 1991) and in other west and central African countries. This traditional technology is equally present in Amazonian Bolivia. The preparation method consists of peeling of the fruits with the hands, then cutting the pulp into small pieces, and air drying them for few days. The dried pulp is then ground in a wooden mortar or a corn grinder. The flour produced is mixed with boiling water to prepare an elastic pastry (*alama* in Nigeria and *foufou* or *fufu* in Cameroon) which is eaten with various sauces. The colour of the flour obtained is more or less dark due to the action of browning enzymes. Some improvement of this traditional method (Figure 11), by blanching the plantain pulp at 80_C for 5 minutes and cutting them into round pieces (or by soaking the round pieces for about 3 minutes in a sodium metabisulfite solution (41 g/1) containing 3 g citric acid, followed by draining and drying in a drying oven at 65_C for

48 hours or in the sun for some days resulted in the production of a more or less whitish flour (Ngalani, 1989). Plantain flour containing 10 percentage of residual humidity and hermetically packed in plastic sachets can be kept for many months without deterioration of its qualities. Plantain flour can be used in different ways.
Flour made from ripe plantain (stage 4 to 5 of ripeness) has been used in making bread, biscuits and instant flour (Ngalani and Crouzet, 1995). Bread obtained by partial substitution of wheat flour by 7.5 percentage plantain flour was not significantly different from that made with wheat flour alone. Extruded biscuits had equally been made with a mixture of millet flour (33.2 percentage), plantain flour (17 percentage), groundnut cake (25 percentage), sucrose (20 percentage) coconut (4 percentage) and sodium chlorite (0.8 percentage). The rehydration properties of instant flour obtained by grinding extruded biscuits were comparable to those of commercial flour, with initial absorption rates two to three times higher (Ngalani and Crouzet, 1995). The *soyamusa*, a baby food from plantain flour (60 percentage), full fat soybean flour (32 percentage), sucrose (8 percentage), fortified with 0.15 percentage of multivitamins and 0.85 percentage calcium carbonate have been made and used in Nigeria (Ogazi et al., 1991; Ogazi, 1996). Recent work carried out at CRBP Njombé (Cameroon) have defined simple formulations for fritters and cakes from plantain flour (Figure 12) well appreciated by consumers (Morelle, 1997). The cakes were obtained by cooking a homogeneous pastry in the oven at 150_C for about 50 minutes. Pastry for cakes was made from 100 g plantain flour, 60 g sugar, 40 g fresh semi-skimmed milk, 10 g butter, 5.5 g baking powder, 3 g of pieces of lemon peel and 1 egg. The pastry for fritters can be made with either a mixture of 250 g plantain flour, 100 g fresh semi-skimmed milk, 75 g sugar, 50 g butter, 5.5 g baking powder, 2 g of pieces of lemon peel, 0.5 g salt and 3 eggs ("*beignets merveillés"*) or 63 g water, 32 g plantain flour, 25 g butter, 7 g sugar, 0.5 g salt and 1 egg (*"beignets soufflés*"). The fritters are thus obtained by frying small balls of these homogeneous pastries in refined vegetable oil (palm, groundnut and cotton) at 140-150_C for about 10 minutes. The quantities of the ingredients in the mixture for the various fritters and cakes can be modified and adapted according to the taste of the consumers.

Figure 12, "*Beignets merveilles*" and cakes from plantain flour produced in Cameroon (photo. J. Tchango Tchango)

1.3 Secondary and derived product

Other uses of plantains

Jams, marmalades, juice, vinegar, beer and alcohol can be made from ripe plantain fruits. In some towns and villages in the region of Ife in Nigeria, a non-alcoholic drink called "*sekete*"

is prepared by women. They take ripe plantain fruits that have been peeled and soaked in water for 2 to 3 days, then filter this mixture to obtain a drink which is bottled and sold locally (Ohiokpehia, 1985). Also in Nigeria, Ogazi (1996) reported the production of beer from over ripe plantain pulp with alcoholic content of 5 percentage v/v and specific gravity between 0.998 and 1.0034. These uses are however more typical of banana than plantains. In Uganda and other East African countries (Burundi and Rwanda) for example, beer bananas are very often used for the domestic production of beer frequently consumed in these regions (Davies, 1993).

1.4 Requirements for export and quality assurance

Bunches or fruit qualities of plantains are judged by important criteria at all stages in the market chain irrespective of the cultivars (N'da Adopo, 1993). Different standards are applied by individuals in the distribution network to assess plantain quality: (1) bunches with well filled fingers and sufficiently round fruits at the time of harvest, (2) fresh fruits without cracks, (3) fruits without mechanical damage, (4) well defined orange rose pulp, and (5) fruits without pest or fungal attacks.

Besides market trends, it was noticed in Cameroon that other factors affect the price of a bunch of mature green plantains (N'da Adopo et al., 1996). These factors include bunch quality at harvest (size, weight, level of finger filling and the colour of the pulp) and its freshness given transportation and storage conditions. A good bunch can cost twice the price of a poor bunch.

Plantains for exportation are carefully handled and transported to preserve the original fruit quality. Handling of those sold locally contrasts sharply with the fragile and perishable nature of the product.

Certain diseases significantly affect fruit qualities. Cercospora diseases caused by Mycosphaerella fijiensis and M. musicola reduce the filling of fingers resulting in about 30-percentage yield reduction. (Momambo, 1993). All known plantain cultivars are susceptible to these fungi. Good disease control can be achieved with fungicides belonging to triazole and benzimidazole groups. As costs continue to rise, the need for resistant hybrids becomes imperative. Cultural practices used to control such diseases include good drainage (Jeger et al., 1995) and frequently stripping off the leaves with necrotic tissues. Some fungi are responsible for post-harvest diseases, which affect the quality of the banana and plantain fruits. For example anthracnose caused by Colletotricum musae provokes the decay of fruits during ripening. Incidence of anthracnose may be reduced by removal of inoculum laden banana and plantain trash from packing areas and by avoiding injury to fingers and pedicels during harvesting and packing (Jeger et al., 1995). Anthracnose may also be controlled chemically after harvest with spray or dip treatments using fungicides (thiabendazole, imazalil, etc). Cigar-end rot disease caused by Trachysfera fructigena and Verticillium dahliae renders fruits unsatisfactory for consumption. Placing polythene sleeves over the stems before the hands come out (Jeger et al., 1995) effectively controls cigar-end rot disease.

2. Post-harvest Operation

2.1 Pre-harvest operations

Plantain is a climacteric fruit. During their growth, there is an increase in size of the fruits and accumulation of starch. This increase in size stops when the fruits reach total physiological maturity.

Theoretical determination of the harvesting stage of Cavendish banana (Ganry, 1978) showed that increased fruit diameter in the absence of limiting soil factors is a function of the total

daily temperature from the appearance of the last hand of the bunch up to the harvest stage (3/4 full or 34 mm grade). The total daily temperature is defined from a 14 ºC threshold, which represents the minimum temperature permitting the growth of bananas. The total daily temperature is equal to [(0,4 x T max) + (0,6 x T min)]-14. In optimal conditions without constraints other than temperature, a total cumulative temperature of 900º C is required to obtain the theoretical optimum harvest stage of dessert bananas. The same growth model applied to French Sombre plantain (N'da Adopo, 1992) confirms that bunches of this plantain cultivar at the 3/4 filling stage are obtained at total cumulative temperature between 900 and 1000ºC. Bunches harvested at full maturity (bunches with well filled fingers and some few ripe fingers) correspond to a total cumulative temperature of 1200ºC. In practice, this model is not apparent to most plantain producers who usually don't work in optimal farming conditions.

In practice, harvest maturity of fruits will depend mostly on the target market. Plantains for local markets are harvested at a more advanced stage of maturity than those for exportation. The maturity indices are based on the age of the bunch, the interval between flowering and harvesting (IFH), the filling of the fingers or the colour of the skin and pulp. The filling of the fingers is the criterion mostly used. This standard is typically completed by other visual criteria like the evolution of the peel colour of the fruits. Most of these criteria depend on the cultivar. If the filling of the fingers was combined with the colour of the pulp, evaluating harvest maturity could become more objective (Marchal, 1993). This leads to the definition of three stages of fruit maturity: non-angular fruits with pale and whitish pulp (stage 1), rounded fruits with well-coloured pulp (stage 3), and stage 2 between stage 1 and 3. The interval between flowering and harvesting (IFH) is also an objective criterion, which can be grounds for harvest decision. Using the practical IFH and the evolution of average temperature, it is possible to define in each ecological zone an IFH chart according to the seasons and cultivars.

Other maturity indices like pulp to peel ratio, fruit firmness, diameter and length of the fruits reported by Thompson and Burden (1993) are less useful for traditional plantain producers. Investigations on the best standards to address yield requirement, bunch quality and the conservation of green mature plantain by analysing stages of harvesting remains a priority in producing countries.

2.2 Harvesting

The usual method of harvesting plantains is to partly cut through the pseudostem approximately 2 m from the ground or at upper thirds with a machete. This allows the plant to bend over under the weight of the bunch. The bunch is then cut off and taken away while the pseudostem is left in the plot. The pseudostem is then cut into pieces to reconstitute the organic matter. The stages involved in harvesting a bunch of plantain are shown in Figure 2. This mode of harvesting exposes the fruits to mechanical damage, especially when no precautions are taken to prevent the bunch from falling on the ground (Wainwright and Burdon, 1991; Dadzie, 1994). In the case of dwarf types, bunches can directly be cut off and removed from the pseudostem without cutting it into sections.

Figure 2a-2d:
Stages involved in harvesting a bunch of plantain without mechanical damage (photo J. Tchango Tchango)

The use of plastic forms is recommended to protect bunches of plantain during harvesting and transportation to the packaging site in the same manner as exportation from industrial plantations. This reduces mechanical damage and avoids reduction of fruit quality of plantains for exportation.

2.3 Transport

The handling techniques of plantains before marketing are generally less adapted to the fragile and perishable nature of the product. In the producing countries of central and west Africa, hands or entire bunches of plantains are combined with other agricultural products in baskets and pans and carried on top of a person's head home or to sell by the roadside. Hands or single fingers can also be packed with other agricultural products in bags to facilitate transportation. Generally in Cameroon, men transport plantains on their heads, behind their bicycles or motorbikes or in rickshaws to their houses or to be sold. Packages of 2 to 3 bunches of plantain are jointed to each other. Women in certain regions of Cameroon carry bunches of plantains in baskets hung on their backs from the plantation to their homes or selling points (Figure 3).

Figure 3: Transportation of bunches of plantains to the market by women in the region of mile 20 in the South West province of Cameroon (photo J. Tchango Tchango)

In markets located in the production zones, the bunches of plantains bought from the villages are piled up on one another (Figure 4), then loaded in bulk in trucks (Figure 5) or vans for travel to big distribution and consumption centres situated at times hundreds of kilometres away. The bunches are piled up to maximise loading and to expedite transportation. They are unloaded without caution at the destination. These different modes of packaging and transportation expose the fruits to damage and low market quality (Marchal, 1990; Wainwright and Burdon, 1991; Dadzie, 1994; N'da Adopo et al, 1996).

Figure 4: Bunches of plantains piled on one another while awaiting loading in truck at the Mile 20 market in the South West province of Cameroon (photo J. Tchango Tchango)

Figure 5: Loading bunches of plantains in bulk in trucks at the Mile 20 market in the Southwest province of Cameroon for transportation to urban centres (photo R. Achard)

2.4 Packaging

Figure 6: Reusable plastic cages, which could be used for packaging and transportation of plantain hands (photo J. Tchango Tchango)

Dehanding plantains in the field and packaging the hands in reusable plastic cages reduce mechanical damage and preserve the fruit quality during transportation. An example of reusable plastic cages, which could be used, is shown in Figure 6. The utility of this packaging is not obvious in many producing countries as peasants and intermediate wholesalers are accustomed to bunches. In addition, they are not prepared to bear additional costs or extra investment to buy plastic cages for local sales.

Bunches of plantains exported by ship from Cameroon to Gabon are transported in bulk by ship, without any particular care similar to those sold locally since the trip is about 48 hours. Plantains exported to Europe and North America are superior quality compared to those sold locally. A high grade of false horn type plantains is in great demand in these countries. In Cameroon, plantains exported to Europe by air are harvested at normal maturity and packed under perforated plastic film in well-ventilated cartons. This method is used to export dessert bananas. Plantain exported by ship in containers or in refrigerated docks (12-14_ C) should be harvested much earlier to avoid ripening during transportation (about 15 days). They are handpacked under perforated plastic film in cartons after soaking them in a solution to avoid the development of fungi during transportation. Studies are underway at the CRBP bananas and plantains regional research centre in Cameroon to determine the optimal harvest period of fruits for plantain cultivars (Big Ebanga, Bâtard and French Clair). This study intends to ensure crop conservation at 12-14_C in the mature green stage during transportation to Europe. Export by ship would enable participants:

- To compete with the higher costs of transportation by plane in Cameroon and in other producing countries;
- To increase the profit margin;
- Promote the development of the production of plantains to ensure high export tonnage.

In Central America, the false horn Cuerno and the bâtard Dominico-harton are the most exported cultivars to North America (United States) and Europe (FHIA, 1993; Lescot, 1993). Single fruits are packed in normalised cartons after soaking in a fungicide solution containing 35 ppm of thiabendazole (0.0035 percentage) and 1000 ppm of imazalil (0.1 percentage). Afterwards the cartons are placed into pallets and transported in refrigerated containers (8 to 9_C) to North America and Europe (FHIA, 1993). In the European market, plantains from Latin America seem to be of inferior quality since they ripen poorly during marketing compared to those transported by plane or by ship in optimal conservation conditions (12 to 14_C and 85 to 95 percentage HR).

2.5 Storage

In producing zones and at the local distribution market, bunches of plantains are generally stockpiled in bulk (Figure 4). However, simple methods intended to reduce the desiccation and the evapotranspiration rate of fruits are occasionally used within the traditional distribution channel to maintain a certain level of freshness and an acceptable quality for a number of days. These measures include precautions to limit mechanical damage to fruits, stocking bunches under shades shielded from the sun and protection of piles of plantains with leaves of banana or bags regularly moistened with water.

Studies carried out in Côte-d'Ivoire have shown that bunches of plantains (Offoto and Orishele cultivars) harvested at normal maturity stage can be kept green in peasant farms for 14 to 20 days at 302_C and 24 to 27 days at 202_C. This assumes that bunches are harvested when fingers are well filled or rounded and wrapped in plastic bags (8/100 mm) mixed with powder of dry cocoa leaves or rice husk. They will be preserved without remarkable modifications of their organoleptic characteristics (Agbo et al, 1996)

Traders who want to sell their plantains at the ripe stage generally induce the ripening process by stocking them in baskets, drums or other containers covered with plastic bags or jute bags to maintain heat among fruits. These containers are ventilated by removing the covers after 2 to 4 days.
Studies carried out on the conservation of plantains recommend that they be packaged in suitable plastic bags to reduce air circulation. In addition, the use of low temperatures (12 to 14_C) to extend the green life span and maintain the fresh quality of fruits is advised (Hernandez, 1973; Ngalani, 1986; Marchal, 1990; Collin, 1991). These modern techniques of conservation require an investment (purchase of appropriate plastic bags and storage equipment, installation of positive cold store, electricity bills, etc.). Traditional plantain producers and traders would hardly adopt them. All storage attempt to prolong the shelf life of mature green plantain should be preceded by an economic analysis of the system in place: network type, stage of harvest, market value and price after conservation (N'da Adopo et al; 1996). The use of refrigerators or appropriate plastic bags would then be necessary only in the long distribution channel to great distances to supply the non producing zones where selling plantains at a higher price will justify the establishment of such a technology.

3. Economic and social considerations

Research and development programmes for the post-harvest systems of plantain focus essentially on the improvement of conservation and transformation techniques of the product, and the reduction of post-harvest losses for a more consistent supply. In the analysis of a post-harvest systems, technical description (presentation of methods, tools or innovations) alone is not sufficient and should therefore be complemented by socio-economic evaluation. The idea behind this approach is to appreciate the technology at the disposal of the operator, proposed technology, the technical constraints, but also the economic and social constraints. In most cases, the operator has at his disposal the methods and expertise, which correspond to his environment.
The evaluation of the advantages and disadvantages of the current procedures must be the first step in the intervention process (Nago et al., 1993). All interventions to improve an existing system (introducing modern conservation or stocking techniques, etc) must be preceded by an socio-economic evaluation.
To evaluate a technique, it is advisable to define criteria from the beginning (Guéneau, 1994). The measures often adopted are:

- Efficiency
- Impact
- Viability/reproducibility
- Participation/satisfaction of the operators.

The significance of each standard will depend on the specific methodology considered. The measure of the efficiency of a technique compares the results obtained to the financial, human and material means available. Following the identification, assessment and cost-benefit analysis, the probability for its adoption is then determined. For instance, the cutting up of bunches into hands, followed by packaging in reusable cages is a technique that reduces mechanical damages and improves fruit quality. However, it appears that this technique leads to supplementary investment which operators are not ready to incur. There is no certainty that consumers will accept a plantain price increase sufficient to gain the return of investment. Analysis of the viability of a technique consists of estimating the capacity of the operator to master and carry forward the technique. The challenge is to overcome not only the technical constraints but also the economic ones. Can a success with a new technology be sustained and repeated?

The analysis of the impact of a technique consists of appreciating the effects that this can have on the environment in its broadest sense:

- Technical impact (improving traditional techniques or introduction of new techniques);
- Economic impact (creation or loss of employment and the increase or decrease of income);
- Social impact (effects of this technique on the operator prestige, on social cohesion and harmony, and on social organisation of labour);
- Ecological impact (destruction or protection of the environment).

The participation and satisfaction of the operators contributes to the evaluation of the technique at the operator levels. For more complete information on this point, the opinion of potential operators who refuse the technique should be collected. Possible unfavourable effects that the technique could have on certain groups should not be concealed.

3.1 Proposed improvements

Plantains and other cooking bananas produced throughout the humid tropics constitute a major source of carbohydrates and contribute to the food security for millions of people in Africa, the Caribbean, Latin America, Asia and the Pacific. The modes of consumption vary from one country to another depending on the eating habits. Production systems are mostly of traditional type and are dominated by mixed cropping of plantains with other agricultural products (coffee, cocoa, yams, cocoyams, etc). In some countries, plantain monoculture is reported. The improvement of the production systems of these food-stuffs must permit not only the increase in the quantities produced but also the improvement of the fruit quality. This can be achieved through the development of techniques for a better management of pests and diseases as well as a harmonious and durable land use.

All programmes for the improvement of post-harvest systems in plantain should be aimed at objectives defined on the basis of technical criteria (improvement of production technique, improvement of packaging, handling and transportation methods, development of appropriate preservation techniques), social (reduction of laborious operations), economic (income improvement and market reinforcement). The programme generally includes 4 phases:

1. A diagnostic phase to understand the technical system and identify variables that need innovation. This essentially consists of technical and socio-economic evaluation of the system (its functional advantages and constraints, achievements, the expectations and the means of the operators). This next leads to an action plan used as a basis to search for solutions.
2. A phase in search for technical solutions which takes into account the objectives of different actors of the system, their environment and their resources. The options to be investigated are not always adapted to the different situations. It is necessary to adjust them or to conceive new ones.
3. An experimentation phase carried out with different actors under normal conditions. Experimental demonstrations with actors should be considered as training phase. For example, when testing an equipment, training on installation, functioning and maintenance should be organised.
4. A follow up and evaluation phase for the gathering of information on the improved system. The information is then treated and technical options can be adjusted for real situations.

An improvement programme based on such procedures enables within record time to effectively support the existing dynamics and to actually meet the expectations of operators. Any study aimed at improving the post-harvest system of plantain should consequently take into account the contribution of the government (repairing roads and tracks in the production

areas, dissemination of research finding and results, subsidising of fertilisers and pesticides, organising the market, etc) as well as the other operators in the plantain network (producers, wholesalers and retail traders, transporters, consumers, etc).
The "commodity chain" approach seems to be better for the global analysis of the system. This global and multidisciplinary approach will include a socio-economic aspect to understand the motivations and logic of the actions of the different actors in the chain (researchers, producers, transporters, retailers, consumers and manufacturers), and a technical aspect to evaluate the technical characteristics and to determine the variables for the development of the production and the improvement of the post-harvest system.

4. References

Agbo, N.G., Soumanou, M. and Yao, K.A. (1996). Nouvelles techniques de conservation de la banane plantain en milieu rural avec de la matière végétale. *Sciences des Aliments, 16(6): 607-621*.
Collin, M.N. (1991). Allongement de la durée de vie verte du bananier plantain par différentes techniques de conservation. *Rapport de recherche*. pp. 62. IRFA.
Dadzie, B.K. (1994). Traitement post-récolte des bananes plantains au Ghana. *Infomusa, 3(2): 9-10.*
Davies, G. (1993). Production domestique de la bière de banane dans la région de Mpigi, Ouganda. *Infomusa, (1): 12-15.*
FAO. (1987). Root and tuber crops, plantains and bananas in developing countries: challenge and opportunities. *Plant Production and Protection Paper No 87.83.* Rome, Italy.
FAO. (1989). *FAO production yearbook.* Vol 43. Rome Italy.
FHIA. (1993). *Manual de plantano*. pp. 112. Fundacion Hondurena de Investigacion Agricola (FHIA).
Ganry, J. (1978). Recherche d'une méthode d'estimation de la date de récolte du bananier à partir de données climatiques dans les conditions des Antilles. *Fruits, 33(10): 669-680*.
Ganry, J. (1990). Quelques indications sur la production et la consommation de bananes et plantains dans le monde. *Fruits, numéro spécial, pp. 17-18*.
Grimaldi, J. and Bikia, A. (1985). Le grand livre de la cuisine Camerounaise. pp. 258. Sopécam, Yaoundé.
Guéneau, M.C. (1994). Le suivi-évaluation. *L'appui aux producteurs ruraux*. pp. 125-159. Coord. Mercoiret, M.R. Ministère de la Coopération/Karthala. Paris, France.
Hernandez, I. (1973). Storage of green plantains. Journal of Agriculture of the University of Puerto Rico. 57(2): 100-106.
INIBAP. (1992). *Annual report 1992*. pp. 7. International Network for the improvement of Banana and Plantain (INIBAP).
Jeger, M.J., Eden-Green, S., Thresh, J.M., Johanson, A., Waller, J.M. and Brown, A.E. (1995). Banana diseases. *Bananas and Plantains*. pp. 317-381. Gowen, S., ed. Chapman and Hall. London, UK.
Lemaire, H., Reynes, M., Ngalani, J.A., Tchango Tchango, J., Guillaumont, A. (1997). Aptitude à la friture de cultivars de plantains et bananes à cuire. *Fruits, 52(4): 273-282*.
Lescot, T. (1993). La culture du bananier plantain en Colombie et dans les pays andins. *Fruits, 48(2): 107-114.*
Marchal, J. (1990). Contraintes post-récolte et perspectives d'amélioration de la manutention, du stockage et de la transformation du plantain et des autres bananes à cuire en Afrique de l'Ouest. *Fruits, 45(5): 439-445.*
Marchal, J. (1993). Qualité des bananes de dessert et des plantains. *Fruits, 48(1): 40-44*.

Momambo, K.N., Gault, F., Vuylsteke, D., Ortiz, R., Pasberg-Gault, C. and Swennen, R. (1993). Yield loss in plantain from black sigatoka leaf spot and field performance of resistant hybrids. *Field Crop Research, 35: 35-42*.
Morelle, S. (1997). Production et utilisation de farine de plantains et bananes à cuire. pp. 22. *Rapport de stage effectué au CRBP de Njombé au Cameroun du 1er Juillet au 29 Août 1997*.
Nago, M., Thuillier, C. and Hounhouigan, J. (1993). Etude des systèmes techniques de transformation artisanale de maïs au Bénin. *Alimentation - Techniques et innovations dans les régions chaudes*. pp. 385-404. Coord. Muchnik, J. Harmattan. Paris, France.
N'da Adopo, A. (1992). Réduction des pertes après récolte des bananes plantain. pp.119. *Rapport de bourse*. André Mayer, ed. FAO. Rome, Italy.
N'da Adopo, A. (1993). La qualité et la filière après récolte de la banane plantain au Cameroun et en Côte-d'Ivoire. *Fruits, 48(2): 125-132*.
N'da Adopo, A., Lassoudière, A., Tchango Tchango, J. (1996). Importance du stade de récolte pour la commercialisation de la banane plantain au Cameroun. *Fruits, 51(6): 397-406*.
Ngalani, J.A. (1986). La conservation des fruits tropicaux: cas de la banane plantain. Etudes préliminaires. *Fruits, 41(2): 89-92*.
Ngalani, J.A. (1989). Valorisation du plantain: étude de l'obtention, de la caractérisation et de l'utilisation des farines - Conservation en frais. pp. 159. Thèse de Doctorat d'Etat. Université des Sciences et Techniques du Languedoc, France.
Ngalani, J.A. and Crouzet, J. (1995). Utilisation de la farine de banane plantain dans la fabrication de pains, biscuits et farines instantanées. *Cahiers Agricultures, 4: 61-64*.
Ogazi, P.O., Smith-Kayode, O., Solomon, H.M. and Adeyemi, S.A.O. (1991). Packaging considerations and shelf life study of a new plantain based weaning food in Nigeria. *Proceedings of the 8th world congress of food science and technology, 29 September-4 October 1991*. Toronto, Canada.
Ogazi, P.O. (1996). *Plantain: production, processing, utilisation*. pp. 305. Paman and Associates Limited. Uku-Okigwe.
Ohiokpehai, O. (1985). Plantains as food in Nigeria. pp.164-165. Proceedings of 3rd meeting of the International Association for Research on Plantain and Banana, Abidjan, Côte d'Ivoire, 27-31 May 1985.
Onyejegbu, C.A. and Olorunda, A.O. (1995). Effects of raw materials, processing conditions and packaging on the quality of plantain chips. *Journal of the Science of Food and Agriculture, 68: 279-283*.
Thompson, A.K. and Burdon, O.J. (1995). Harvesting and fruit care. *Bananas and Plantains.* pp. 403-433. Gowen, S., ed. Chapman and Hall. London, UK.
Treche, S. (1997). Importance de l'utilisation des racines, tubercules et bananes à cuire en alimentation humaine dans le monde. *Les Cahiers de la Recherche Développement, 43: 95-109.*
Ukhum, M.E. and Ukpebor, I.E. (1991). Production of instant plantain flour, sensory evaluation and physico-chemical changes during storage. *Food Chemistry, 42: 287-299*.
United Nations. (1991). African statistical Yearbook, Volume 2, Part 4: Central Africa.
Wainwright, H. and Burdon, J.N. (1991). Problems and prospects for improving the post-harvest technology of cooking bananas. *Postharvest News and Information, 2(4): 249-253*.
Agdex 231/G76 - ISSN 1018-0966

PLANTAIN CASE STUDY

1. Introduction

Post-harvest systems differ fundamentally depending on whether commodity is meant either for consumption in its production area, or for export at international or intercontinental levels. Procedures are linked to various factors:

- Fragility of the product;
- Importance of the relative values granted to quality criteria;
- Existence of recommended and established norms;
- Eating habits;
- Utilisation of sub-products of the commodity;
- Consumer revenues;
- Cultural data.

The evaluation of the system after harvest should consider the type of market.
In the export channels meant to supply remote markets (such as plantain export circuits from Central America to the United States or from Africa to Europe), the product is subjected to the specifications and taste preferences of importers:

- Calibre of fruits;
- Cleanliness;
- Identification of the origin of the commodity;
- Packaging in cartons.

The selling price of the packed and dispatched plantain is meant to encourage producers and exporters to maintain or even improve the quality of their products.
Goods appreciate in price according to its presentation in packaging (packaging is the first criteria that can be observed) and agronomic characteristics. When the product does not adhere to export norms, it is put aside and often enters the local commercial channel.
The different actors of the traditional channel grant a relative and secondary importance to the packaging of the commodity. The most important point here is availability of the product for consumption. The post-harvest system does not place much importance on the state of the product.
Cooked banana plantains are food crops, in Africa mainly consumed in their production areas.
The typical observer often thinks that the rough handling of the crop creates the important losses of the harvest. Logically this would indicate scant availability of this food for consumers with a corresponding drop in revenues of the sellers.
The traditional channel is old using local practices. Actions intended to improve this situation have been confronted with problems. Custom and habit block application of methods used in the international export of dessert bananas.
The evaluation of losses after harvest in traditional channel based on the criteria of international export of banana often leads to exaggeration of the issue.
Despite the importance of plantain and the socio-economic role it plays, post-harvest practices are somewhat identical from country to the country, from continent to continent.
The most recent survey shows that after harvest, physical losses are limited (Kuperminc, 1985; Lendres, 1990 ; N'da Adopo, 1992 and 1993) to scarcely over 5 percent.

Several factors explain this situation:

- Production areas are either locales with great demand, or are not far from them. The product arrives at the market before being unfit for consumption;
- Plantain is consumed at all stages of ripeness. Even those eliminated as a result of rough handling are collected and used. The declassified fruit that is no longer purchased by a category of consumers is sold to poorer people. Beside the standard distribution professionals, there are auxiliary sellers who introduce damaged fruits in a sub-market: Hence everything is eventually recovered;
- There is no excess of plantains when compared with actual eating needs. Plantain is part of food crop production (See Tables 1);
- The producer manages the clusters for his own consumption and does not harvest important quantities of plantains if he thinks that he will not be able to sell them;
- The means used by the intermediary for the acquisition of clusters from the producer and their transport to the consumption market prevents him from accepting the loss of this commodity.

Post-harvest loss of the plantain is generally restricted to the decrease of the commercial value as compared to expected gains.

Table 1. Per capita consumption of the main food crops in Côte d'Ivoire from 1985 to 1990 (kg)

Year	Rice	Maize	Other cereals	Gnam	Cassava	Plantain	Cocoyam	Groundnut	Wheat
1985	57,8	28,7	2,4	118,2	97,2	67,7	8,2	7,0	3,7
1986	58,4	28,6	2,4	115,6	96,8	68,3	8,0	7,0	3,8
1987	59,0	28,5	2,4	113,0	96,4	68,8	7,9	7,1	3,8
1988	59,6	28,4	2,3	110,4	96,0	69,4	7,7	7,1	3,9
1989	60,2	28,2	2,3	108,0	95,6	69,9	7,6	7,2	3,9
1990	60,8	28,1	2,2	105,6	95,2	70,4	7,4	7,2	4,0

(Source: Food crops consumption estimates, July 1987, Statistical office, Ministry of Rural Development

The most obvious losses occur in field. The reasons for this are:

- There is no one available to buy non-harvested clusters;
- Loss of potential production due to decrease in yields, destruction of banana trees by hurricanes, parasites, pests and poor soil. (See Figures 1 and 2).

These losses increase with the age of the plantain and can be significant
(See Tables 2, 3 and 5).

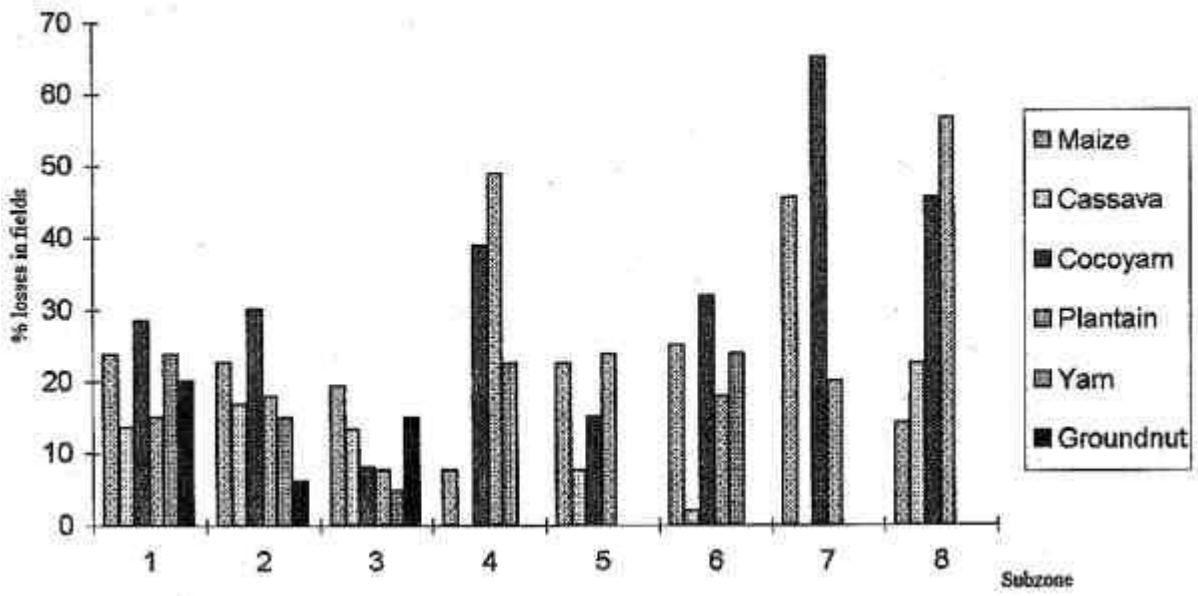


Figure 1: Percentage of some food crops losses in fields in 8 subdivisions of Fako zone, South - west District of Cameroon (TLU, IRA-Ekona, 1987)

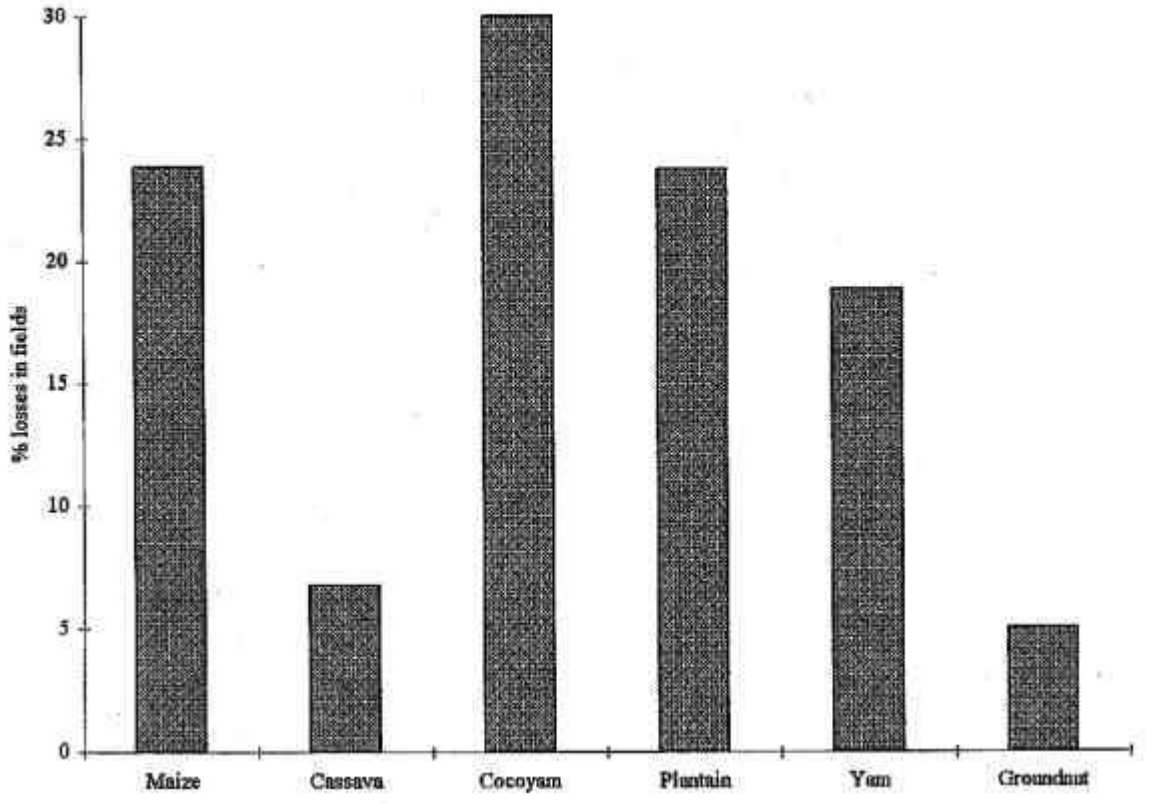


Figure 2: Average percentages of field losses of some food crops in Fako zone (Cameroon)(TLU, IRA-Ekona, 1987)

Table 2: Estimated losses of plantain plants based on age of the plantation (agricultural sector of Kunda Southwest Cameroon)

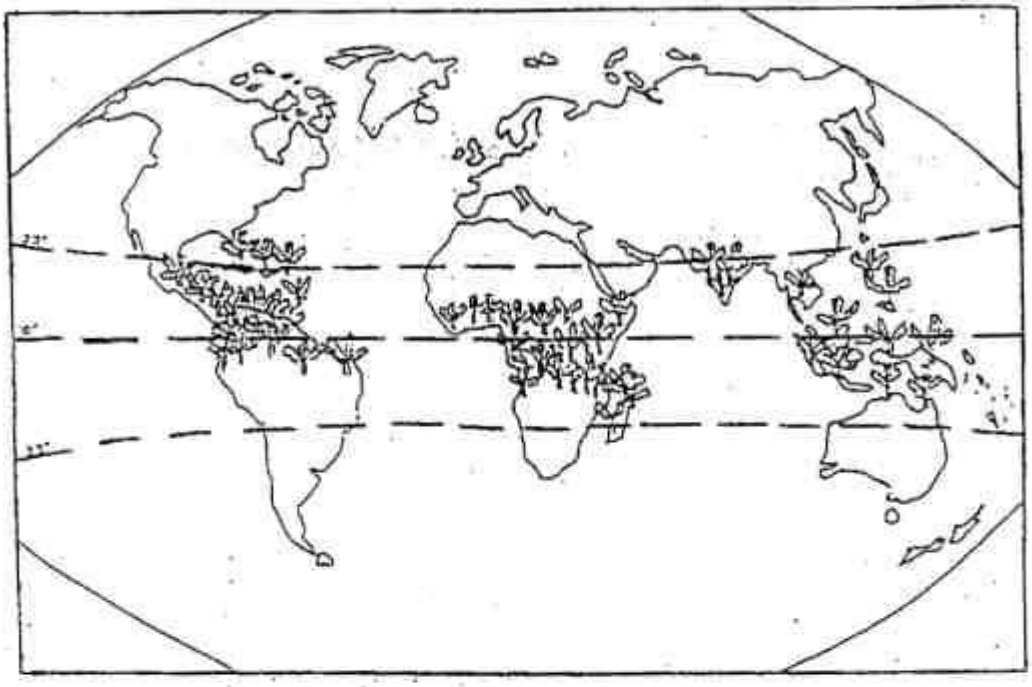
Cropping cycle	Parasites and wind	Mechanical destruction
1	2 - 5	Accident
2	10 - 25	_ 2%
3	20 - 50	

Table 3: Estimated percentages of seasonal distribution of plant decreases caused by hurricanes, compared to all damaged plants (Kumba Zone, Southwest Cameroon)

DRY SEASON	WET SEASON
November - March	April - May June - October
5 % maximum	20 % 95 % 80 %

The channel should be viewed as a global design where methods are balanced with eating habits, the means and tradition. (See Figures 3 and 4).

a) In the world



b) Main regions in Africa

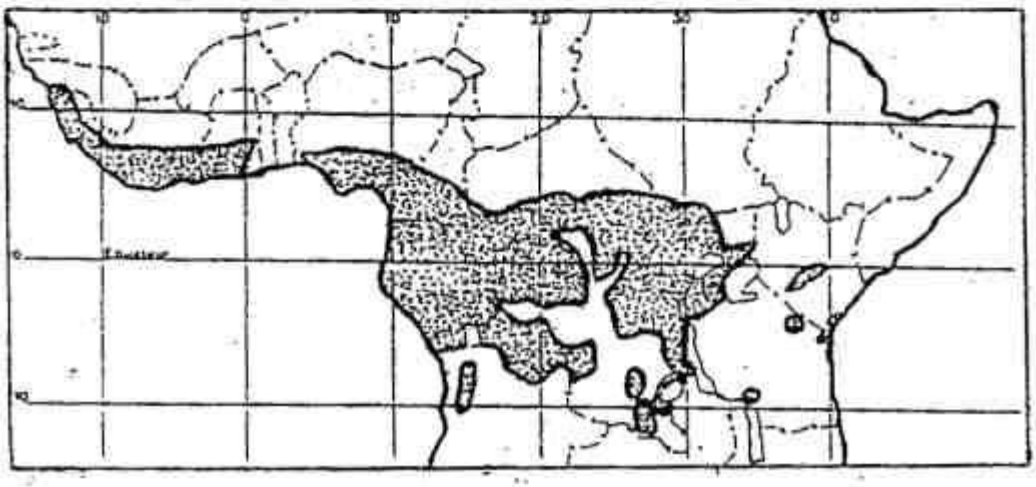


Figure 3: Regions producing bananas plantain in the world and in Africa

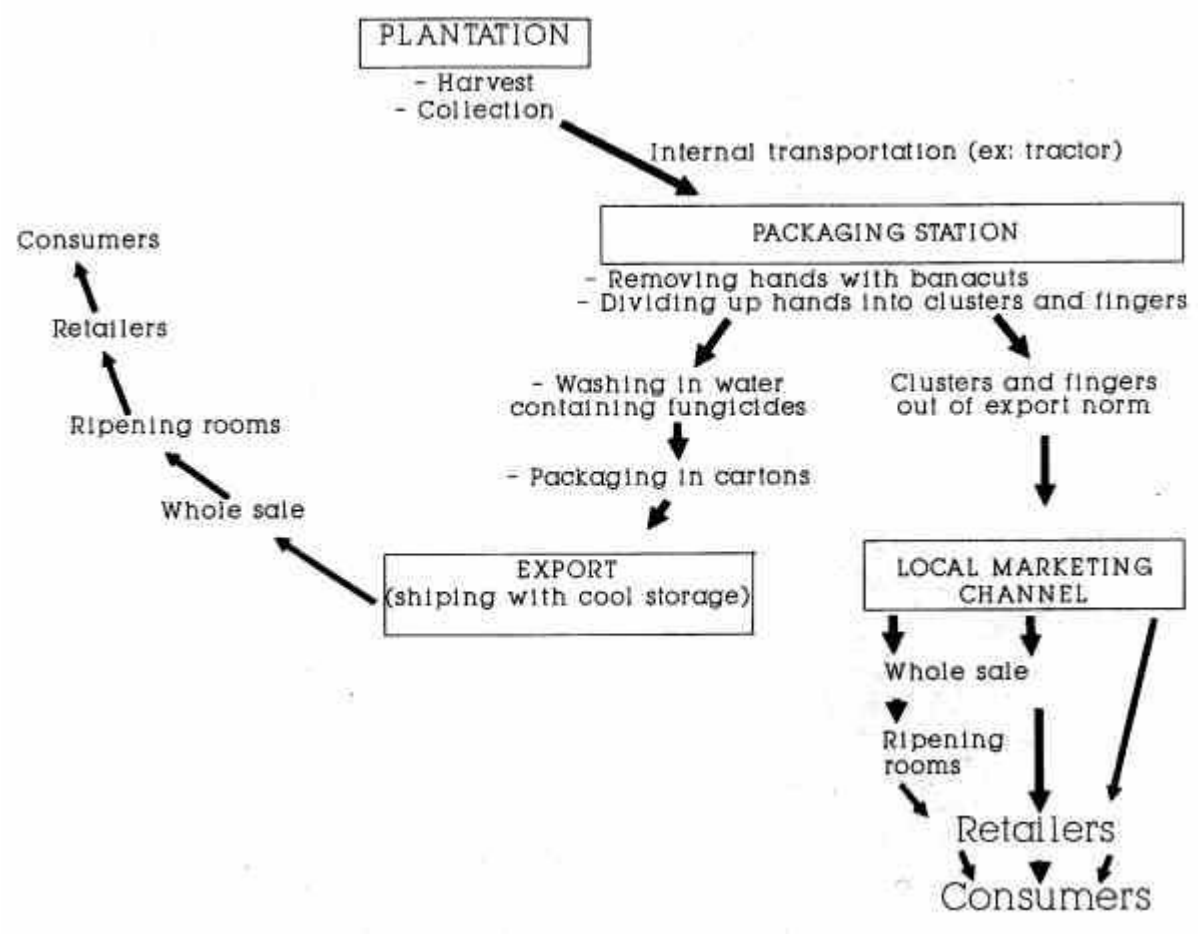


Figure 4: Summary of operations in banana export trade

At the farm level, men (often husbands) manage the commercialisation of the plantain in the field while the product is abundant.

Women are more numerous than men in the distribution circuit. If wholesalers are the sector where men are most represented (more than 50 percent), retail sale of the clusters and fingers is largely dominated by women (more than 95 percent of retailers in Africa).

Mainly adults participate in the distribution of the crop. One often encounters in markets, sedentary retailers more than fifty or 16 years old maximum (See Figures 5a-c). Activities require many trips to visit farms for many days to collect the product, negotiate with carriers, which are accomplished by the most young and vigorous age group. Typical handlers are young men (See Figure 6).

Figure 5a+b+c:
Commercialization takes place in the lorry during unloading

Figure 6: Harvesting bananas for modern trades (export). One handler to cut with a machete and the other to receive the bunch carefully (Simmonds, 1959)

1.1 Economic and social impact of the crop

The classification of banana trees is based on the hypothesis that all edible bananas come from two parents, two species of the *Musa* type: *Musa acuminata* (AA) and *Musa balbisiana* (BB). These two fertile species crossed in the wild state. Letters A and B designate the ploid and composition of gene in these parents (Simmonds, 1959; De Langhe, 1976; Rowe, 1976). The absence of meiose at the level of female gametes caused the formation of AAA, AAB, ABB triploids and even tetraploids (See Figure 7) (Champion, 1976).

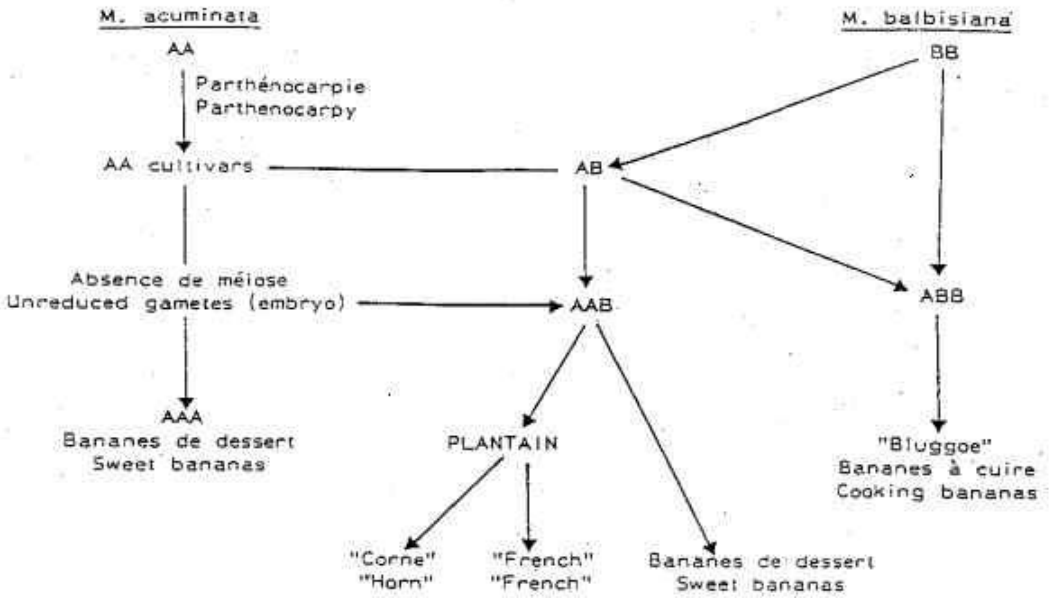


Figure 7: Schematic way indicating origin of bananas and plantains, by Champion (Fruits, Vol. 31, no 9, 1976)

True plantains are triploids AAB, and divide themselves into *French plantain* and *Horn plantain*. Within these two types, there are a great many varieties (cultivars) grown. The *French* plantain cluster possesses a persistent male axis, whereas that of type *Horn* is absent or degenerates quickly after flowering. Several clones of these plantains differentiate themselves mainly by the number of hands, the size of the fruit and the cluster. It is possible to find small, medium, giant French, false and true Horns (See Figure 8). In broad terms, plantain refers to all cooking bananas (ABB).

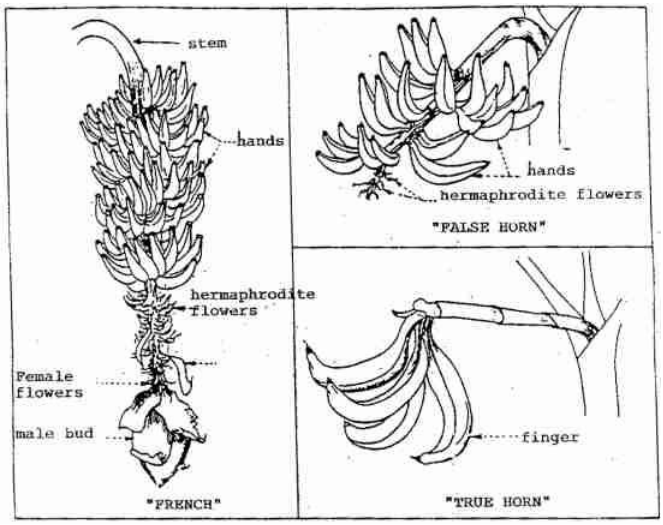


Figure 8: The 3 major types of plantain bunches (source: Fruits, Vol. 38, no 6, 1983)

False Horn and true Horn are found extensively in Côte d'Ivoire (at least 90 to 95 percent of the production). The French species comprise 50 percent of plantains in Cameroon. Rwanda and Burundi are important producers of cooking bananas and of cultivars used for preparing local traditional «beers» called beer bananas.

Table 4: Characteristics of some plantain and cooking bananas

Groups	Name allocated	Length of cycle (forest zone)	Size	Sensitivity to wind	Sensitivity to the black stripes diseases	Drops out	Number of hands per clusters	Productivity	Utilisation
Great French	Essong, Ovang, Zue, Ekon	15 to 18 months	big	very sensitive	sensitive	weak	8 to more than 10	very good	fried, boiled
Medium French	French sombre, French Claire, Elat	12 to 15 months	medium	sensitive	sensitive	good	6 to 8	good	fried, boiled
Dwarf French	Njockkon	18 months	small	a little sensitive	sensitive	very weak	8 to more than 10	good	fried, boiled
False Horn	Big Ebanga, Bâtard, Ebang, Mbouroukou	less or equal to 12 months	medium	sensitive	sensitive	good	4 to 7	medium	roasted, pounded
True Horn	One (two or three) hand plantain	12 months	medium to large	sensitive	sensitive	medium	1 to 3	weak	fried, boiled
Other cooking bananas	Pelipita, Assubu, Baro Baro, Bluggoe Fongamou, Cacambou Popoulou	12 to 5 months	medium	a little sensitive	good resistance to sensitive	good	6 to more than 10	good	fried, boiled (as plantain)
Hybrids to cook	FHIA 1 FHIA 3	14 months 12 months	medium medium	great resistance great resistance	good resistance a little sensitive	medium good	9 8 to 9	good very good	fried, fried

(Source: Le Courrier of C.R.B.P., n_ 38 September 1994, Cameroon)

1.2 World trade

World production of plantain was estimated in 1985 at 25 million tons. Of this 16.6 tons was projected for Africa; Latin America was the second place producer at 4.1 millions of tons (FAO, 1987).

Plantain cultivation is not limited to big plantations but is often grown in small orchards which sometimes go unnoticed (WILSON, 1983). The usual production takes many forms (Chataigner, 1988):

- Next to or behind the home in a garden (generally a maximum of 50 plants),
- On cleared forest, or on swaths in association with other food production (coffee, cocoa).

These fields represent at least 95 percent of cultivation.

They are of modest size as growing areas vary from 0.5 to 4 ha (Tlu, Ira-Ekona, 1987; N'guessan et al., 1993).

Plantain is usually cultivated first for self-consumption, in random form, in rotation followed by fallow. The surplus of available production is sold.
In this crop system of extensive cultivation, densities measure a maximum of 1000 plants to the 1666-advocated yield. Yields are from 3 to 54 tons/hectare. Peasants who use low technology input on poor soil grow the lowest limit. Invariably, technology with high inputs, intensive production to obtain high yields is rarely transferable to peasants due to required initial funding required (WILSON, 1983).
High technology in the pure culture of plantains is rather uncommon in Africa. It is extended to the Caribbean and Latin America who are oriented to export trade.
In despite of its increases, production for export represents a very small proportion of the harvest. The types of distribution are:
- Traditional. Plantains are sent from efficient producing countries to others that produce little or no banana crops. These are mostly border countries: Cameroon to Gabon, Côte d'Ivoire to Burkina Faso;
- Modern (Packaged in cartons). Plantains are sent to North America and Europe. Latin America has a long history of this export and big plantations are dedicated to trade. Andean zone is the biggest producer in the American continent, but export is only 4 percent of production (Lescot, 1993).
The marketing of the production in the Southwest district of Cameroon, stems from five principal productive strategies (TEMPLE and al., 1983):

- Subsistence strategies where small family production is used for the household food-supply;
- Pioneer strategies of migrant farmers who are in zones, which grow plantains;
- Firm strategies where farmers have consolidated their cultivation extension process;
- Diversification strategies of farmers often with a main non-agricultural activity who try to invest in plantain;
- Food-producing strategies in garden or small food-growing plots to supplement family food supplies.
- These strategies depend on four variables:
- Objective of the farmer;
- Structure of production;
- Cultivation system;
- Marketing process.

Table 5. : Economic viability of production systems (cost per hectare)

	Extensive forest system (1st cycle)	Extensive forest system (3rd cycle)	Intensive system (1st cycle)
Production			
Number of plants sown	900	900	1666
% of harvested plants	95	40	90
Weight of cluster (kg)	9,3	8,0	8,0
Production (kg)	7 951	2 880	11 995
Value (FCFA)	214 677	77 760	323 865
Changing price			
Drops			
Number	900	225	1666
Value (F CFA)	45 000	11 250	83 300
Insecticide			
Quantity (kg)	0	0	33
Value (F CFA)	0	0	82 500
Total cost (FCFA)	45 000	11 250	165 800
Gross (1) (FCFA)	169 677	66 510	158 065
Labour (days)*			
Clearing	25.0	7.0	0.0
Making holes	15.6	4.0	29.0
Sowing	9.4	2.3	17.3
Weeding	22.5	15.6	41.7
Treatment	0.0	0.0	1.3
Harvest	40.6	17.0	71.5
Total (2) (F CFA)	113.1	45.9	160.8
Productivity per working day (1)(2) (F CFA)	1 500	1 449	983

*__Note__: Technical coefficients are derived from surveys under actual conditions. The cost retained for plantain is 27 CFA/kg, average price over the production period from September to May at the field border 100 FCFA = 2 FF (French Francs). The duration of a working day is 5 hours. The time of clearing (semi-mechanical) is 51 working days spread over 3 years. Drops or losses are defined as number planted per hectare in the first cycle and number of replacements per hectare Fr the second cycle.
Source: TEMPLE et. al., 1993

The requirement for labour per hectare for the plantain is smaller than that required for most tropical species (See Table 6).

Table 6. Labour requirement for tropical crops

	Plantain	Cassava	Maize	Rice
Day labour /ha	80	310	122	162
Days work/ton	20	31	122	62

Source: Johnston, 1958

The most extensive systems of production could hardly challenge in the short term the present forestry system (TEMPLE and al., 1993).

Table 7: Evolution of plantain production in the most important producing countries between 1971 and 1979 (in thousands of tons) (*)

	1971	**1977**	**1978**	**1979**	**% variation (1971-1979)**
World	16 05	19 536	20 275	20 584	28
Africa	10 404	12 640	13 011	13 285	28
Cameroon	694	950	950	955	38
Gabon	807	1100	1150	1200	48
Guinea	177	212	220	222	25
Côte d'Ivoire	653	750	800	800	23
Kenya	168	205	215	225	34
Nigeria	1635	2000	2100	2150	30
Rwanda	1656	1896	2043	2127	28
Tanzania	539	746	733	746	38
Uganda	2650	3100	3192	3192	19
Zaire	1191	1433	1405	1420	18
North and Central America	1237	1418	1519	1464	18
Cuba	60	130	134	134	123
Dominican Republic	529	531	610	550	4
Haiti	189	198	198	162	5
Honduras	110	153	160	162	47
Puerto Rico	101	102	101	100	35
South America	3210	3897	4255	4336	35
Bolivia	100	153	165	173	73
Colombia	1619	1844	2192	2236	38
Equador	445	770	796	790	77
Peru	654	700	705	742	13
Venezuela	363	406	372	369	2
Asia	1197	1577	1486	1495	25
Burma	406	501	404	425	5
Philippines	402	270	270	270	(-33)
Sri Lanka	389	806	775	800	105

(*) Countries producing more 100,000 tons per year. Source FAO, 1979.

In many producer countries, plantain is used for consumption. Global data often conceal the importance of consumption in certain regions. Consumption is generally highest in producing zones (Melin and Djomo, 1972; Guillemot, 1976). Recent studies indicate that consumption is increasing in urban areas, except within principal production regions (Sery, 1988).

Table 8: Plantain and cooking banana production and utilisation world-wide by region and Africa by country (FAO, 1985)

REGION/COUNTRY	PRODUCTION (`000 t)				
	Total	Export	Feed	Food	Processed
AFRICA	12867,0		28,9	8194,5	2387,6
Cameroon	970,0			630.0	
Central African Republic	65.0			52.0	
Congo	62.0			55.8	
Gabon	170.0			161.5	
Ghana	450.0			585.0*	
Guinea	235.0			188.0	
Guinea Bissau	25.0			20.0	
Ivory Coast	850.0			680.0	
Kenya	225.0			216.8	
Liberia	32.5			29.9	
Malawi	17.5			15.8	
Nigeria	1420.0			1420.0	
Rwanda	2200.0			534.0	1600.0
Sierra Leone	25.0			23.8	
Tanzania	1000.0		20.0	730.0	100.0
Uganda	3410.0			1700.0	511.5
Zaire	1480.0		8.8	1147.0	176.1
ASIA	1718.0			1288.3	
N/C AMERICA	1615.1	23.9	87.9	1119.0	
S AMERICA	4036.9		311.1	3258.3	
OCEANIA	1.3		0.3	0.8	

***Numbers includes imports.**

Table 9- Estimated annual per-person consumption of starchy staples in many countries of the tropics (FAO. 1971)

Country	Per-person consumption (kg/year)			
	Plantain*	Cassava	Yam	Maize
Brazil	39,3	55,5	--	19,2
Cameroon	76,5	104,0	39,8	48,6
Colombia	61,5	21,4	6,0	16,6
Costa Rica	31,2	6,2	--	54,9
Congo	24,6	241,7	--	3,3
Dominican Republic	143,4	27,4	4,5	7,0
Ecuador	65,0	12,4	--	7,3
Gabon	153,6	192,8	52,5	3,6
Ghana	80,7	104,8	97,2	35,5
Haiti	75,1	23,2	4,3	47,3
Ivory Coast	99,5	71,7	166,3	38,7
Puerto Rico	27,0	1,9	4,2	2,3
Rwanda	296,8	15,8	--	12,8
Tanzania	86,8	19,5	--	50,7
Uganda	237,2	95,7	51,6	14,7
Zaire	62,7	264,4	16,2	15,0

* Numbers for Costa Rica, Dominican Republic, Rwanda, and Uganda include banana.

1.3 Primary product

The traditional consumption almost represents the usual form of utilisation. Plantain is consumed regardless of its ripening stage. The green or ripe fruit is boiled in water, chopped up or pounded into a homogeneous paste and may mixed up with peanuts, cassava or yam. Riper plantain is fried in oil after being chopped, mashed or mixed with wheat, cassava or maize flour. The pulps may be cooked by wrapping them in banana leaves. Plantain can also be toasted or dried up.

There is an abundance of recipes for plantain. Naturally certain plantain varieties are preferred to others for different dishes. For example, True and false Horn with bigger fingers are mashed more often than French plantain. The latter are used in recipes that call for chopped plantain. The ripe fruits are used in making traditional wines in Central Africa.

Beyond the usual alimentary utilisation, the different parts of the plant or the fruit are used in traditional medicine in West Africa:

- The coal obtained from the burnt skin of the fruit is used to cure dysentery;
- The juice obtained after cooking the green fruits is recommended for urinary incontinence;
- The ashes of the burnt skin, after being mixed with some water and strained with a low fire, provide a potash which is used in medicines, soap works, and in sauces.

Industrial level chip manufacturing is done in Latin America (Badia, 1985). Chips are more and families in Africa make more. These are sold in the streets or by small and medium companies, which deliver them to supermarkets.

The pulps can be transformed into flour and may be used in various dishes such as nursing porridge (Kiyingi, 1985). The pulps of the ripe fruit can be used in making industrial alcoholic drinks such as wines and liquors.

1.4 Requirements for export and quality assurance

Quality criteria are taken into account when fixing prices at all stages of commercialisation. Quality is judged by objective and subjective criteria, which are likely to change from one region to the other. The opinions of the specialists in the field cover characteristics:
- Cooking flavour and eating habits;
- The physiological maturity at harvest (for example, the degree of filling of the fingers).

The perception of quality will also affect commercial activity:
- Producers prefers high yielding plantains cultivars which have greater resistance both to pests and to drops caused by wind and hurricanes;
- Intermediaries focus on degree of maturity, transport distances and the distribution deadlines. The plantain crops already ripe at the producer level are depreciated because they will be too mature before delivery at the urban market.

The characteristics at harvest and the state of freshness are two basic criteria taken into consideration in the commercialisation value of the plantain.
Traditional criteria identify quality through reference marks of the level of filling, the degree of roundness of the fingers and the colour of the pulp.
Three qualities that define decreasing commercial values are:
- The well filled cluster with well-coloured pulp (Quality 1) (See Figure 9a+b);
- The cluster with medium filling and pulp coloration (Quality 2);
- The lean cluster with a poorly coloured pulp (Quality 3).

Cross and lengthways sections of median portions of corresponding fingers (cultivar *Orishele,* a «*False Horn*» plantain) are shown in Figure 10a-c.
Sometimes professionals add another parameter, which they call «drop» made up of very early and immature clusters from fallen trees (hurricanes, winds). Sometimes these crops are sold when supply is very weak during the low production season (Sections of fingers are shown in Figure 11a+b).

Figure 9a+b:
Well developing bunches of plantain (quality 1). Showing caracteristics of freshness. First cultivar French clair ("French"). Second cultivar Orishele (false "Horn"); See the splited finger in first hand showing a well coloured pulp

Figure 10a-c:
Medium portions of fingers (cultivar Orishele) showing criteria of increasing qualities. From left to right: quality 3, 2 and 1

Figure 11a+b:
Lengthwise (first) and cross (second) section of pulps from cultivar French Sombre showing increasing qualities. From left to right: "drop", qualities 3, 2 and 1

On the banana and the plantain tree, one can notice an increase of the weight of the cluster, of the filling of fingers and the coloration of the pulp during the development of the bunch.
Quality 1 corresponds to the well-advanced physiological maturity and homogeneous filling;
Quality 2 has an intermediary filling and pulp coloration;
Quality 3 comprises clusters of various characteristics:

- Lean fingers with coloured pulp. The plantain is quite advanced in physiological maturity but its yield is low to poor, following bad growth and development conditions (nutritional deficiencies, unfavourable bioclimatology, pest attacks);
- Lean fingers and pale pulp indicating homogeneous physiological maturity resulting from a too early harvest or taken from a banana tree fallen before successful development of the bunch.

The degree of filling is the simplest parameter to observe at markets, because it can be detected from a distance of several meters. It is not necessary to break a finger. The pulp coloration can confirm for the client the maturity of the cluster.
The impact of quality on the commercial value is undeniable. Reports of prices at all stages of the market showed that the clusters of Quality 2 and 3 are worth when compared to those of Quality 1 around 30 percent and 45 percent to 55 percent respectively (N'da Adopo and al. 1997).
When buyers and sellers are bargaining about the maturity of a cluster, freshness is ranked second. The green fresh cluster (See Figure 9a+b) has:

- Brilliant and clean appearance;
- Peducles, which are, firm and can still support fingers in an erect position;
- A shaft which shows a white or whitish-coloured humid wound when it is cut.
- The cluster which has lost freshness (See Figure 12) shows:
- A dirty appearance. There are traces of shocks and wounds inflicted during the various manipulations. These marks are apparent, dark-coloured or black further aggravated by heat and dehydration;

- A dry, soft shaft;
- Falling fingers.

Figure 12:
Type false "Horn" bunches showing signs of loosing freshness.

A study initiated in 1992 in Douala (Cameroon) and in the main zones of the Coastal and Southwest districts which supply towns with plantains, translated the seasonal variations of quality perception by the local producers (N'da Adopo and al., 1992).
These two districts were supplying respectively 63,500 and 245,000 tons (Source: Minpat, Direction of Planning, 1985) or 6.4 and 30 percent of the production of the country. 70 percent of the plantain consumed in Douala comes from the Southwest (Lendres, 1990; CRBP, 1996).
Producers and intermediaries in rural zones generally recognise the rainy season as being the period during which clusters are of best quality. The rainy season corresponds in fact to the period during which the banana tree gets a lot more water. The alternate rain-sun pattern creates good conditions to fill and mature the fingers of the bunches. The study concluded that quality is synonymous with good development, good filling and turgid characteristics of the cluster.
Table 10 (a, b and c) presents the periods and percentages of the clusters of Quality 1 cited by the producers of Zones I, II and III (See Figure 13). Zones IV and V have not been studied, as their production is marginal compared to the first three.

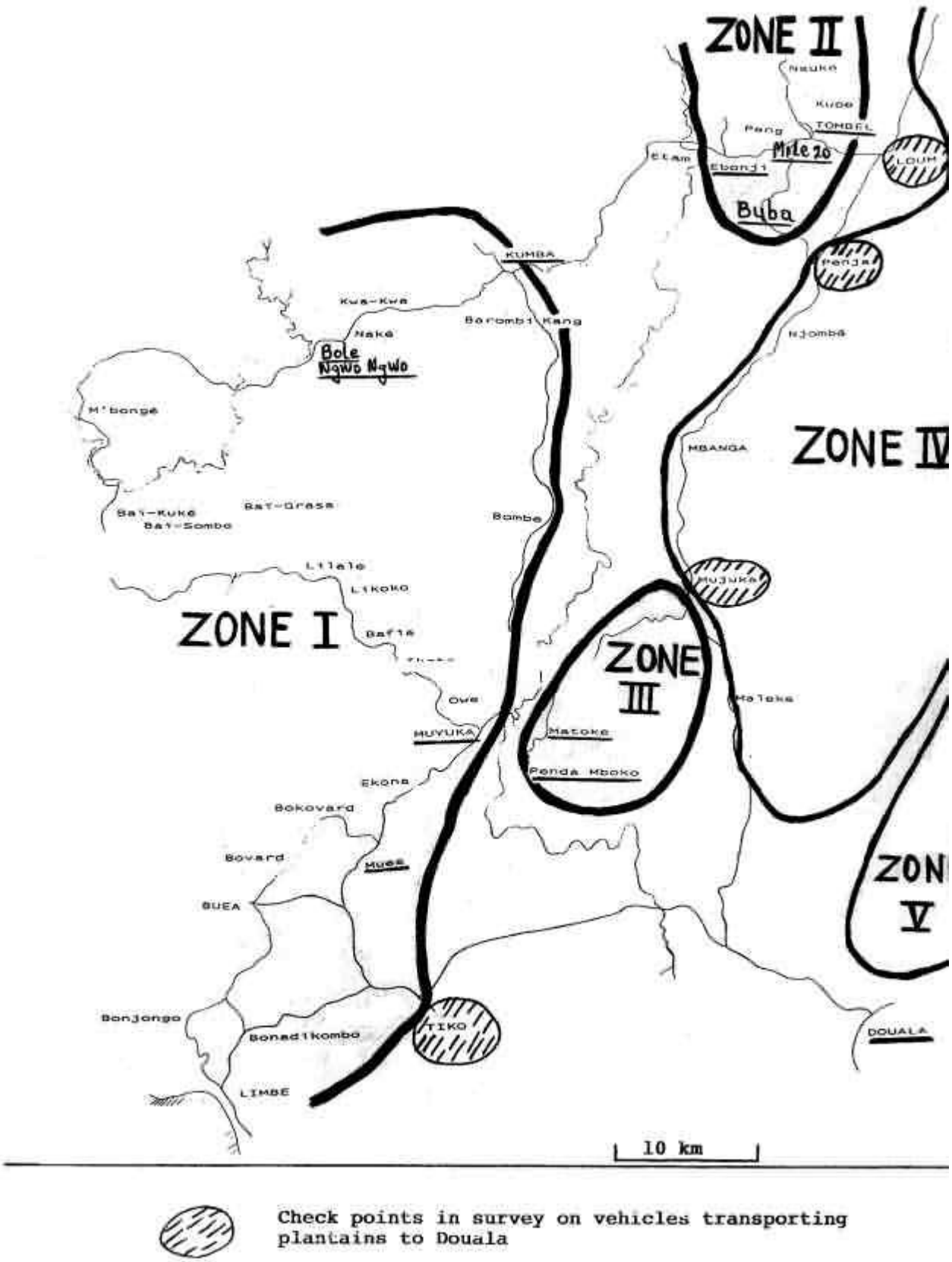


Figure 13: Borders of the major areas of South-West and Coastal Districts which provide Doulas with plantains

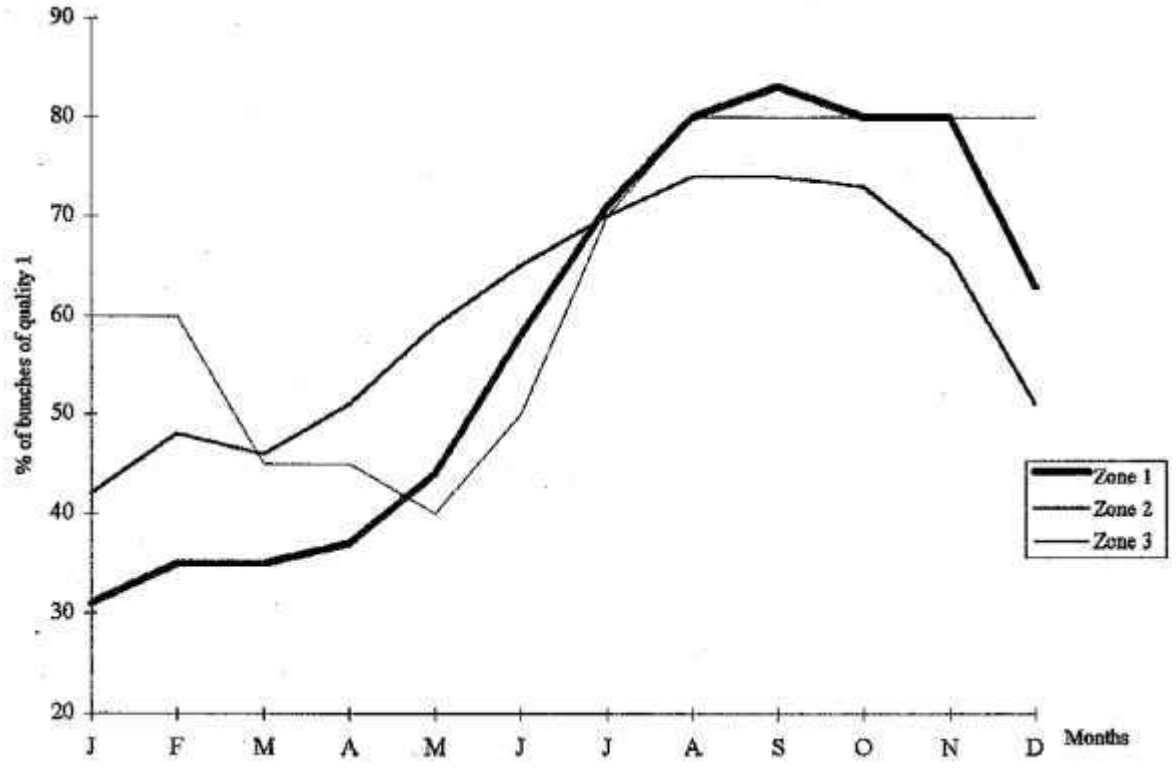


Figure 13b: Calender of quality and percentage of its distribution according with the perception of producers in the major areas providing Douala with plantains (N'Da Adopo et al., 1992)

Consumers in Douala in their majority designated the dry season, as the period during which the rate of Quality 1 clusters is the highest. The dry season (December to March) corresponds to the peak production period (up to 2 times more plantains than in rainy season). During this peak period, banana trees often suffer from heat and a certain proportion of clusters do not reach maximum filling.
In the rainy season (June to September), conditions are more conducive for better development of the fruits; but production is weaker. Producers often harvest when filling is still insufficient, because they are sure to sell the cluster.

Table 10: Calendar of quality and percentage of its distribution during the year in the surveyed production zones

+ = Period of large proportion of banana plantain of Quality 1

- = Period of small proportion of banana plantain of Quality 1

a) Regions of Kumba, Muyuka and Muyenge (Zone **I**)

Areas	J	F	M	A	M	J	J	A	S	O	N	D
Muyenge	- 20 à 30						+	+			+	50 à 90 + +
Liliale	- 20 à 40					-		+			+	60 à 85 -
Likoko	- 20 à 40					-				+	60 à 80	- - -
Bafia	- 25 à 30					-				+	50 à 90	+ - -
Muyuka	- 25 à 35					-	-	-				50 à 90 + +
Yoke	+	- 30 à 70					-				+	50 à 90 + +
Owe	-	- 30 à 40					-	-				+ 50 à 90 +
Kumba	+	- 25 à 40					-	-				+ 50 à 90 +
Mabanda	+	+	-20 à 40					-	-			- 80 à 90 +
Molyko	- 30 à 50					-	+			+	+ 50 à 90	+ + +
Mutengene	+	+	-	40	-	+	+	65 à 85				+ +
Tiko	+	-	-	20	-			+	50 à 90			+

B) Region of Tombel (Zone **II)**

Areas	J	F	M	A	M	J	J	A	S	O	N	D
Buba 1	- 40					+	+			50 à 70		+ +
Buba 3	- 25 à 50						+			+	80 à 90	+ - -
Ebonji		-	45	-	+	+	75 à 95					+ +
Ngap **(_)**	+	80	+	+	-	30 à 50					-	+
Mile 20	-							+ 90			+	-
Bulutu	-	30	-			+	+	70	+	+	+	-
Mahole	-	30	-			+	+ 50 à 70					+ +
Ehom	-	40	-			+	+	75	+	+		-

(_) The soils of this area contain often-excess water during wet season.

c) Region of Penda Mboko (Zone **III**)

Areas	J	F	M	A	M	J	J	A	S	O	N	D
Penda Mboko		-	- 40			-			+	+	80	+ +
Matouke	+	+	-	50	-			+	+	+	+	+

Banana plantain has not been covered by well-defined international criteria, as is the case for export banana. One may adapt existing specifications to plantain, on the basis of current methods and data. Côte d'Ivoire specifications concerning banana plantain for export (NI 01.02.001) mainly applies the regulations of fresh bananas intended for export.
Fingers should:

- Be normally developed, full, firm, fresh, green and free from ripeness marks, black spots and rust marks;
- Be healthy without scratches, wounds and no symptoms of sunburn. Crops should be free of storage pests or marks affecting the commercial value;
- Be clean, free from processing products or visible foreign matter and dust;
- Held by healthy peduncles which are not broken, twisted or mouldy. Fingers should not be missing inside hands.

In the traditional sector, ripeness for harvest of several cultivars of reduced or medium size (Corne 1 and 4 in Côte d'Ivoire, French Sombre and Bâtard of Cameroon, Orishele of Nigeria) is reached between 75 to 95 days after discovery of the last female hand.
The formula of thermal sums used to forecast the harvest of export bananas (Ganry, 1978) was tested on plantain at CRBP (N'da Adopo, 1993).
The daily thermal sum is equal to:
(0.4 X t_ maxi + 0.6 X t_ mini) - 14
Is defined with a threshold of 14_C, the temperature threshold for growing bananas.
The corresponding features with the French sombre cultivar between the calculated thermal sums, the intervals since flowering (stage of last female hand discovered), the weight of clusters, the degree of fingers filling and pulp coloration (in accordance to IRFA colour scale on banana, Figure 14a) and quality criteria defined by professionals of the traditional sector, is summarised in Table 11.

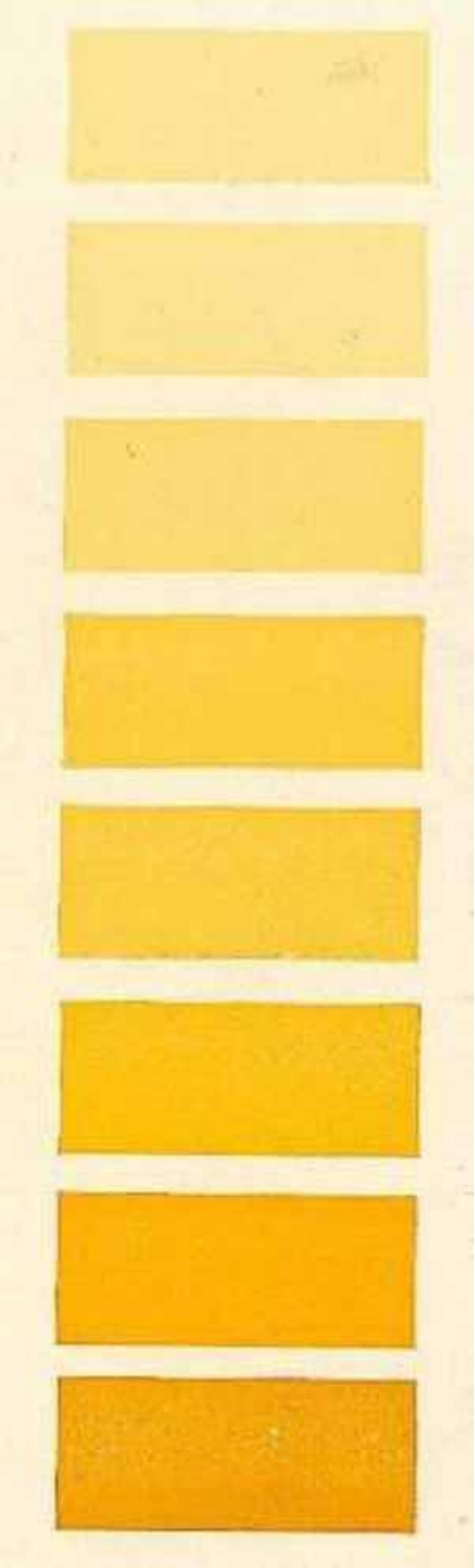


Figure 14a: Colorchart of banana pulp according with french norm for export (IRFA, 1980)
Figure 11a+b and Table 11 present increasing characteristics of filling (in accordance to Figure 14) and coloration observed during this trial.

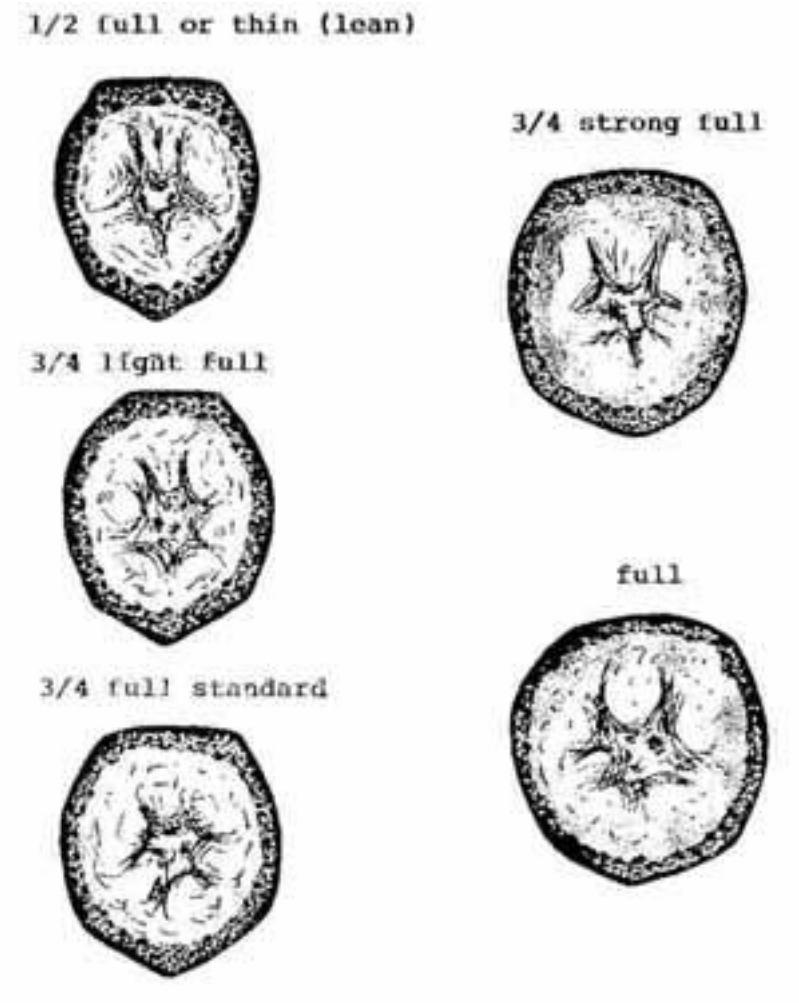


Figure 14: Schematic cross section of banana according to different levels of development (IRFA, 1980)

Table 11: Quality at harvest of the French sombre cultivar in the traditional sectors (characteristics per official regulations)

Quality	«Drop»	3	2	1
Thermal sum (_C)	800	900	1000 à 1100	1200
Interval flowering-harvest (days)	61	69	77 to 84	94
Level of filling	< 3/4	3/4 lean	3/4 light to 3/4 full	3/4 full to 4/4
Pulp coloration	< 5	5 to 5,5	6 to 6,5	7 to 8
Medium weight of clusters (kg)	13	15	17	17,2
Medium living leaves at harvest	6,4	6,4	5,47 to 5,08	4,14

2. Post-Production Operations

Banana plantain belongs to climacteric fruits characterised by temporary increase of respiration (Cheftel, 1976). This sudden increase of respiration is called climacteric phase or crisis, which precedes or coincides with observed changes during ripening of plantain:

- Progressive fading of the green colour of the skin;
- Brutal decrease of the hardness of the pulp;
- Occurrence of aromatic flavour.

During its development on the tree, the hardness of the pulp of banana reaches a maximum point that is approximately 2/3 of the growth cycle of the fruit. Then hardness decreases continuously until harvest (Deullin, 1966).

Hardness measurements of the pulp of the plantain on French sombre and Orishele cultivars during their development indicate a permanent decrease of the pulp breaking strength from 65 to 70 days after dropping of female flowers. This stage corresponds to hardness pics for a growing and development cycle of the cluster of about 100 days (corresponding to the maximum yield) (Sery, 1985).

The change of the colour of the skin from green to yellow, the softening of the fruit and characteristic odours, constitute the most practical and fastest physical characteristics signalling the ripening of the plantain.

The decrease of the hardness of fingers (the pulp breaking strength), practically nil at the climacteric stage, has a very important consequence for the fruit as it is subjected to brutal handling in the traditional sector. After harvest, the finger, even if it is still very green, softens continuously and becomes less and less breakable compared to the freshly picked. This phenomenon considerably reduces the number of fingers broken or removed normally encountered during loading and unloading operations.

The period of green life or pre-climacteric phase is closely linked to the harvest stage. The time between harvest and ripening decreases as harvesting is delayed.

In the commercialisation sector, clusters are often harvested when they have nearly reached the ultimate stage of development. In these conditions (air temperature from 24 to 35_C, hygrometry from 70 to 90 percent), ripening occurs in 5 to 7 days. This corresponds very often in the traditional sector to the length of time between harvest and delivery to the most distant urban markets (400 to 700 km).

Traditional cropping provides the most important share of production (at least 80 percent of commercialised clusters). In this production system, the offer is not regular. One can consider as very good the selling on a weekly basis of 10 to 20 clusters by a producer after his self-consumption needs. The gathering by intermediaries can last from 2 to 4 days. The cluster, which has reached the consumption market then, has a potential of green life duration that is quite limited.

If intermediaries can choose the plantain in the stages of filling they want, they cannot control the accelerated loss of freshness in a system where goods are not carefully handled, are piled-up and finally exposed to direct sunshine directly on the floor or the tarmac (See Figure 15).

Figure 15:
Poor storage conditions meaning quick decreasing of initial commercial value of clusters
Cluster protection is easier at the producer level: waiting for the arrival of buyers, the plantain can be placed under the shade of banana trees and covered with their large leaves. This type of product storage under good conditions without any cost, has the advantage of banana leaves cut at the same time as the cluster are laid down to avoid scratching crops against the floor during harvest (See Figure 16). This process also allows the farmer to slow down ripening of the cluster for a few days, pending the arrival of the buyer. Intermediaries are more at ease to bargain for reduced prices when damage is obvious or when there are important signs of loss of freshness of the product.

Figure 16a-d: Harvesting for sale by the producer

When the buyer abides by his collection calendar, plantain is removed from the producer at green stage. The ripening will occur only at the level of the intermediary, during transport or on the stalls in the consumption market.

If one thinks that after harvest, ripe clusters are more likely to bring about post-harvest losses than green clusters, one should recognise that in the current traditional system, methods to reduce possible losses are relatively more efficient at the level of producers than at the level of intermediaries. Post-harvest manipulations with intermediaries are the same in all the

producing countries and this brings about the same effects on plantains, that is ripening and a quick loss of commercial value (Mihailov, 1986; Kuperminc, 1985; N'da Adopo, 1993).
Rapid ripening of the product during commercialisation may be attributed to several factors:

1. Harvest stage and harvest techniques;
2. Packaging mode and type of transport;
3. Storage and conservation modes.

Generally, the cluster that is in the commercial process will follow one of these two patterns:

- Ripening before loss of freshness;
- Ripening after loss of freshness.

(See Table 12).

Table 12: Aspect of the clusters found on markets of different traditional channels in Cameroon, Côte d'Ivoire and Ghana, according to levels of filling of fingers and commercialisation duration from harvest

	Early or medium stage of harvest	Advanced stage of harvest
Distribution deadline 1 to 3 days	* green cluster* fresh or withered	* green or ripe cluster* fresh
Distribution deadline 4 to 6 days	* green cluster* withered	* well ripened cluster
Distribution deadline 7 to 9 days	* green or ripe cluster* withered	* well ripened or rotting cluster* withered

The cluster which has reached maturity and which is ready for harvest presents certain external characteristics:

- Rounded and very little angular finger lines (the earlier the harvest, the more angular the lines);
- Increase of green pigmentation of apex of fruits;
- Drying of finger tips;
- Drying of floral pieces;
- Presence of cracked fingers or ripe fingers (generally at the level of the first hands).

At this stage, the plant presents only 4 to 6 living leaves maximum against 8 or more at the beginning and middle of the growth and development of the cluster.
The degree of filling for harvest varies according to eating habits, cooking and destination of clusters. Harvest for immediate domestic consumption in Côte d'Ivoire, could produce ripe fingers whereas for sale the cluster will be full and green. The Horn and false Horn plantains are often more rounded than those of French type at harvest.
At the cutting stage (75 to 95 days) of medium size cultivars (Corne 4 and French sombre comprising 5 to 8 hands), many big clusters comprising at least 10 hands (for example cultivar Essong in Cameroon) often present angular fingers, due to the reduced number of leaves which are alive and capable of ensuring an important photosynthetic activity for quick filling of so many fingers (Osafo, 1986).
Tables 13 and 14 present data at harvest obtained from Orishele and French sombre cultivars. Hardness of the pulp is measured at the level of median transversal cut of fingers using a crossbow penetrometer of Cosse type (6 mm diameter nozzle).

Table 13: Pulp hardness in kg/cm²

Harvest stage (days after loss of flowers)	65 à 71	75 à 80	85 à 95
Orishele	2 - 1,8	1,8 - 1,6	1,5 - 1,2
French Sombre	4,6 - 4,3	4,3 - 4	4,1 - 3,2

Table 14: Pulp/skin weight ratio

Harvest stage (days after loss of flowers)	65 à 71	75 à 80	85 à 95
Orishele	1,3 - 1,5	1,5 - 1,65	1,6 - 1,7
French Sombre	1,15 - 1,3	1,3 - 1,5	1,5 - 1,7

2.2 Harvesting

Harvest is done for self-consumption (1 to 3 clusters per week), for sale to possible buyers alongside the road or village track (about 10 clusters maximum) or on request of intermediaries. The number of clusters in the later case depends on demand and supply of the producer compared to the clusters, which have reached physiological maturity.
Harvest is performed to avoid or reduce damages (See Figure 16). A technique often used in Latin America and Africa is to do use a big knife commonly utilised for fieldwork called a *machete*. An oblique wound of 6 to 8 cm is made in the wrong trunk at approximately 0,8 to 1,5 m under the level of the last hands in the axis of the cluster.
The depth of the wound in the wrong trunk should be reduced inversely by the size of the cluster. One can slightly shake the plant by kicking at the level of the wound with the back of the machete. Placing a fork under the stave can also monitor the fall of the cluster. The cluster will be held in the middle by its rachis before being separated from the tree.
When this technique is mastered, the product does not suffer from any shock. The operation requires a maximum of 30 seconds. There are practically no losses in the field due to post-harvest practices.
Harvest for self-consumption, in the field or behind the hut is incidentally done by both sexes. Harvest of larger quantities of clusters (about 10) for sale are generally undertaken by men (the husband, a planting agent, etc.).
The length on which the stave is cut often depends on the destination of the product:
1) Show the freshness of the cluster. It will then be possible later on to cut it one or many times according to the length of sale, in order to present a fresher section to the clients and convince them that the cluster has been harvested that day or for a few hours only;
2) Identify the owner of the cluster, the producer or intermediary puts marks or writes initials on it).

2.3 Transport

In the traditional channel, the plantain is generally transported in clusters from the field to the farm and from one intermediary to the other. The cuttings into hands, bunches or fingers occurs at the last stage of commercialisation with the detailers.
The type of transportation varies according to the number of clusters to be carried, the distance to run and local removing methods:

- Carried by people (1 to 3 clusters);
- Trolley pushed or pulled by people (15 to 25 clusters);
- Bicycle or motorcycle (1 to 7 clusters);
- On the roof of travellers' transport van (50 to 60 clusters);

- Truck (400 to 700 clusters);
- By railway (more than a thousand clusters).

Clusters are thrown into the vehicle, piled-up one on top of the other, without any care. The major concern is to convey maximum of the product while occupying all the available space. One overloads the vehicle in order to make one trip only. These careless operations bring about twisting of peducules, breaking and dropping of many fingers (Figure 5c, 17 and 18). The practice in general in Africa (Mihailov, 1986).

Figure 17:
View of a lorry (7 tons) full of bunches at arrival at the urban market. Approximately 500 bunches are piled into the vehicle.

Figure 18:
Pile of broken and removed fingers during handling and transport, collected below the lorry. According to the lot of bunches in the left, these fingers are equivalent to 50 bunches.

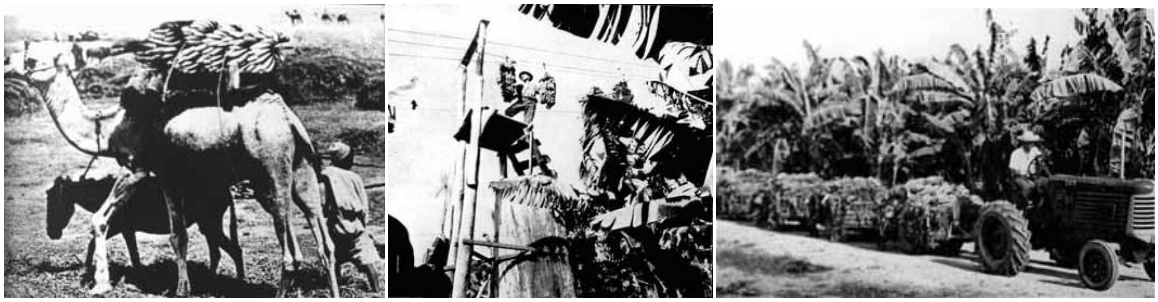


Figure 18a-c:
Transport in the past (Simmonds, 1959)

Most commonly, the carrier is not the owner of the clusters; he is only charged with the responsibility to transport goods to destination. To load or unload 7 to 8 tons (450 to 650 clusters) requires at each destination, 3 to 4 specialised goods handlers apart from the carrier. These goods handlers are real auxiliaries of the channel. These goods handlers wait on the premises where the collected plantains are gathered at he level of producers and on the markets of destination of the clusters. The work is done in sequence:

- A loader «a specialist>> is charged with arranging the clusters in the truck following a process that he masters. One makes sure to arrange the clusters tightly, sometimes breaking them or twisting the fingers;
- Another «specialist» loader (the identifier) in urban market arranges on the fruits in lots, referring to the initials marked by intermediaries on the staves;
- The last goods handlers transmits to the first ones the clusters in one direction or the other, according to loading and unloading situation.

Five to 6 seconds are necessary to throw a cluster into a truck and place it tightly that makes approximately 1 hour for all the collected goods. The identification of clusters and their classification on arrival in town requires as much time. It takes a total of 2 hours to load and unload 500 clusters. The cost of loading or unloading of a cluster including its identification and sorting was 10 F CFA per cluster in the Southwest district of Cameroon (N'da Adopo, 1992). The transport of the cluster per truck (7 to 8 tons) of this district up to Douala cost 180 F CFA. Compared to the costs in abundant periods, 500 F CFA/cluster at the producer level, 915 and 1000 F CFA respectively for wholesaler and detail sale, revenues and charges are shown in Table 15.

Table 15: Gains estimates (F CFA) of the various actors according to the type of circuit: Road Tombel (Zone II) to Douala in high production season (December 1990 to February 1991). Reference: 500 clusters, medium weight _15 kg/cluster.

Type of circuit	Producer himself	Retailer (supplying from the producer)	Wholesaler (supplying from the producer)	Retailer (supplying from the wholesaler in town)
Buying cost from the producer		250.000	250.600	
Individual transport Douala-Ngoussi-Douala	5.000	5.000	5.000	
Collection:- loader	5.000	5.000	5.000	
Collection - other handlers	5.000	5.000	5.000	
Transportation of clusters	90.000	90.000	90.000	
Unloading- off loaders-	5.000	5.000	5.000	
Unloading identifier	5.000-	5.000	5.000	-
Charges	110.000	115.000	115.000	-
Gross return	-	-	365.000	-
Selling price (wholesale) (Douala)	457.500	-	458.330	458.330 (buying in bulk from wholesaler in town)
Net return (wholesale) (Douala)	347.500 less production cost	-	93.330 (186 F/bunch)	
Return (retailer)	-	365.000	-	-
Retail selling price	500.000	500.000	-	500.000
Net return in retail in clusters in Douala	390.000 less production cost	135.000 (270 F/cluster)	-	42.000 (84 F/cluster)

Source: (N'Da Adopo, 1992)

Although product losses during transportation are scarce, this stage is the most delicate and risky of distribution. The harvested plantain can be lost totally or in part in the following situations:

- Lack of respect for the appointment or collection deadline of the harvest by the intermediary;
- Mechanical failure or accident of the vehicle during transportation, immobilising goods for several days.

2.7 Packaging

Plantains are not placed in particular packaging in the traditional channel inside the country of production or between neighbouring countries in Africa. This happens for export to more remote markets, from Africa to Europe, and from South America to North America (Lescot, 1993). Packaging and all other operations try to follow the methods of the international commercial distribution of bananas.

More caution is taken for products destined for export:

- 2 people to harvest a cluster (one to cut, the other one to receive on a back with a foam carpet);
- Take the harvested product to the spot where it is going to be cut near the field or packaging warehouse, hang it on a gantry;
- Cut into hands or fingers with adapted tools («banacut» to remove hands, special knife, etc.);
- Wash and possibly soak in a fungicide;
- Package into cartons for transportation.
- An analysis of packaging coast has been carried out, in hypothesis that 500 clusters (according to Table 15) are cut up and packed in cartons, in a field or on a farm and conveyed for sale in Douala (N'da Adopo, 1992):
- The shaft represents approximately 9 percent of the weight of the bunch. So the net weight of a bunch being able to pack is 13.65 kg, net weight of the 500 clusters is 6,825 kg (hands and fingers);
- The usual packages (cartons used to export bananas) are full at optimum with 19.0 kg of plantains; 6,825 kg require # 359 cartons;
- Handling and packaging;
- Cutting up.

The time required for this task is 1 minute per cluster per person. Therefore 500 clusters require 8.33 hours. It is necessary to recruit 9 handlers to complete cutting in 1 hour. Eight other packers are required to wash and clean the fruits before packaging.

To package requires 2 minutes per carton per person, or 3 hours per person for 359 carton It is advisable to recruit 3 persons. There is a requirement for 28 persons (8 for harvesting and 20 for cutting up and packaging) to finish these operations in 1 hour. The pay for agricultural labour is 110 F CFA /hour /person in the area of this study (Zone III, Figure 13), or 3 080 F CFA in total.

Loading the 359 cartons in the lorry requires 3 handlers, which 20 F CFA in total per carton (See Table 15), or 7 180 F CFA.

Total theoretical charge minimum is 10 260 F CFA (loading would require only 10 000 F CFA in the traditional circuit).

How many cartons are in the lorry?

- The dimensions (in meter) of the trailer of usual lorry (7 tons) are 5 (L) X 2.18 (W) X 0.26 (H) # 19 m3
- The dimensions of banana carton are 0.45 (L) X 0.35 (W) X 0.26 (H) = 0.04 m3.

A lorry can so contain 19/0.04 = 475 cartons. One needs 116 other cartons (and 162 clusters) to complete the loading, that is to say 662 clusters in total: for the same cost, it is cheaper to transport 662 corresponding to 475 cartons than 500 clusters.

But this method requires buying cartons. The cost of a carton is # 600 F CFA, that is to say an initial input of 285 000 F CFA. One carton can be used only for 4 to 5 trips in loading and

unloading. In addition to these charges, it needs also workers to collect the cartons and keep them in the market places during marketing!

2.8 Storage

The producers harvest for self-consumption or an imminent sale. Contrary to the case of rice or maize, one doesn't stock so perishable product on the farm: There are no storage coasts at the farm level (See Table 16).
Harvesting takes place little by little according to the self-consumption needs. When these needs are satisfied and there are no buyers, the clusters are not harvested and plantain can ripen on the trees. The salesman provides his stand with clusters little by little according to the market. The objective is not to stock because the plantains will loss their freshness and their value.
Because the demand for well-ripened plantain is high, many sellers cover the fruits to accelerate ripening. They also use chemical products, which generate ethylene to obtain the same result (See Figure 23).

Figure 19:
In urban markets plantains are usually covered by sellers to accelerate ripening. See the little girl behind watching the stall.

Table 16: Handling Costs (NGN/t of plantain)

	Producer	Wholesaler	Retailer
Transportation	16	43	39
Storage	0	91	15
Handling	16	134	54
Transportation cost as % of handling	100	32	72
Storage cost as % of handling	0	68	28

Source: Njoku J.E. and Nweke F.I., 1985

3. Overall losses

Two types of infections must be discerned:

1) Those which act on the plant by causing a bad development of the bunch;
2) Those which affect the fruits directly before or after the harvest.

Bad nutrition and poor soils cause a delay in the filling of the fingers in conformity with the age of the bunch. The fruits are thin and the pulp is coloured or even with an advanced coloration (yellow dard in some cases in the phenomenon of "yellow pulp").
The bunches often display a poor appearance. Ripening frequently happens on the plant before the harvest stage.
Water outages in the soil and continued droughts lead to similar effects.
Parasites and spoilers: Attack of underground organs
Weevils and nematodes attack respectively the stumps (formation of galleries) and the roots of the banana trees. The incidences on vegetation and the profits are disastrous (Kehe, 1985; Sarah, 1985):

- Section and breaking of the tubes conducting the sap;
- Early destruction of the bulb;
- Section and destruction of the roots.

The consequences are:

- A bad water and nourishing alimentation from the soil; banana trees remain puny and they vegetate. The production becomes inadequate and the plantation gets old quickly.
- The plants fall down with the least wind blow, chiefly from the flowering period when the fruits start to be filled and when they begin to increase in weight.
- The bunches from those banana trees can be classified as Quality 3.

Aerial agents

Black Sigatoka, a fungi disease of the foliaceous system causes falls of the production that can reach more than 50 percent. There's a defect of filling with the fruits of affected plants and they can no more reach their optimum size. Some attacks cause an important destruction of the plantations in Central America, reducing practically to nothing plantain exportations from affected plantation in Honduras (Stover, 1985). Bunches coming from those plantations can no more satisfy the minima requirements in quality and size. Moreover, they grow ripe too early when they're being transported (Bustamente, 1985).
Two types of infections must be discerned:

1) Those which act on the plant by causing a bad development of the bunch,
2) Those which affect the fruits directly before or after the harvest.

Bad nutrition and poor soils cause a delay in the filling of the fingers in conformity with the age of the bunch. The fruits are thin and the pulp is coloured or even with an advanced coloration (yellow dard in some cases in the phenomenon of "yellow pulp").
The bunches often present a dim aspect. Ripening of the fruits frequently happens on the plant before the stage of habitual harvest.
Water outrages in the soil, continued droughts, and lead to similar effects.
In some areas fall in plantain production leads to increases in food prices (Mouliom Pefoura, 1985).

In the usual traditional plantain crop system, it is impractical for the producer to resort to fighting pests with chemical products suited for banana or plantain plantations intended for exportation (Foure, 1985). Those methods require:

- The use of systematic fungicides by pulverisation or spreading;
- Aerial treatment.
- The impact of the disease on the commercial level appears more pronounced in industrial plantations (in particular for exportation) than on the traditional market:
- Lack of average (norms);
- The affected bunches are classified in the category corresponding to the filling level and to their pulp coloration and then sold or consumed by people without any other quality concerns.
- When fruits are attacked they become enormously undervalued:
- Tip disease;
- Dry rots of the ends of the fingers;
- Black spots; at an advanced stage of development, the skin is ready to crack;
- Anthracnose leads to black marks. The development of the disease causes the rottenness of the fruit when getting ripe during the maturity period).

Fungi attacks are particularly noticeable during the wet season. They cause quicker ripening of the fruit before harvest. Direct infections on bunches which provoke a rather repulsive aspect of the fingers are the only causes of rejection of the crop in that traditional channel. Removing the residual floral pieces of the tips of fingers with the casing of the bunch in a plastic protection at the end of the flowering period, treatment with fungicides, work to fight those diseases.

If removing residual floral pieces can't be done (a few minutes maximum per bunch) by the traditional producer himself, by means of a ladder (which he can make by himself), the buying of plastic protection cases and treating products and their employment, may not be profitable when taking into account the prices of banana plantain in the traditional channel.

5. Economic and social considerations

When we speak of rapid ripening of plantain in the system, the first thought is post-harvest losses. People then try to use another system, which is much more liable to reduce loss. A commonly recommended solution is to initiate methods to keep fruit unripened for as long as possible.

This principle conflicts with several problems:

- Actors are mostly interested in well-filled and high weight and short green life of the clusters. They know that filling of fingers (See Figure 20) and weight of bunch increase more and more with age. They seem to have no concern about the issues of diminishing green life of clusters
- The physical post-harvest losses are relatively low;
- Ripe plantains are demanded at the markets.

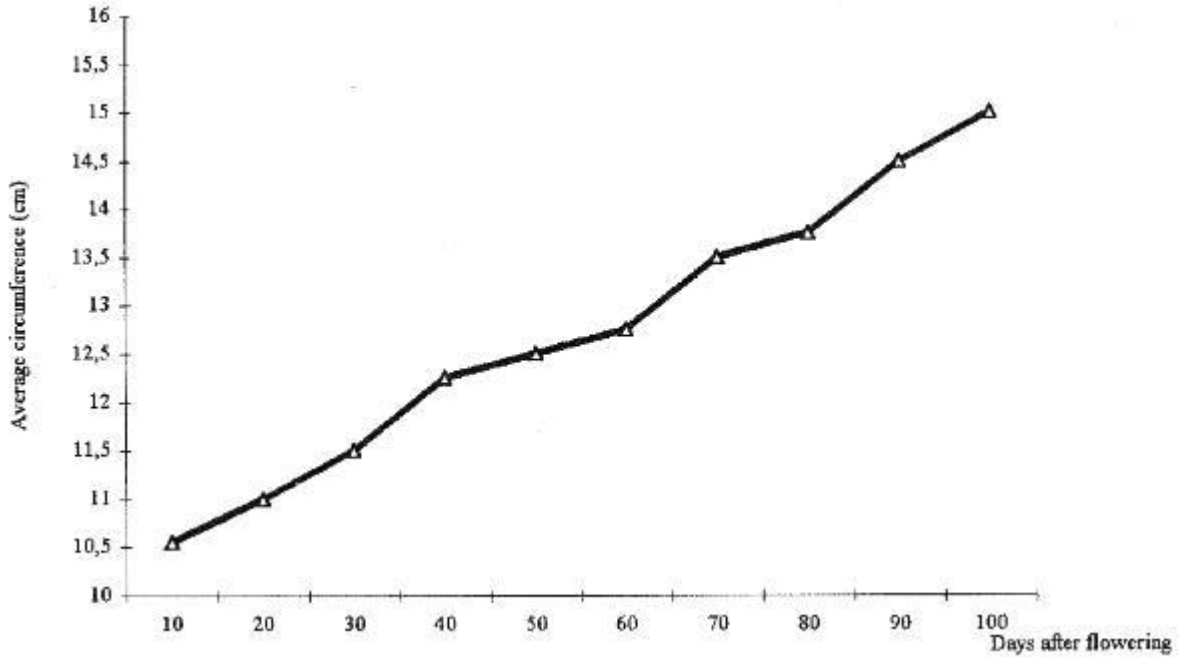


Figure 20: Increasing of medium cross section of fingers (second hand, Orishele) during development

The price of ripe banana is at least equal to that of unripe plantain. The ratio of ripe fruit to unripe fruit can reach 1,5 and 2 in some regions, particularly during periods of less production. Figure 21 describes the price evolution of two bunches (one is Quality 1, the other is Quality 3) during commercialisation in an urban market place (N'da Adopo, 1996): the value of a well ripening cluster increases and after decreases at stage of super-ripening. The fact that sellers select their goods to accelerate ripening illustrates this point (See Figure 19).

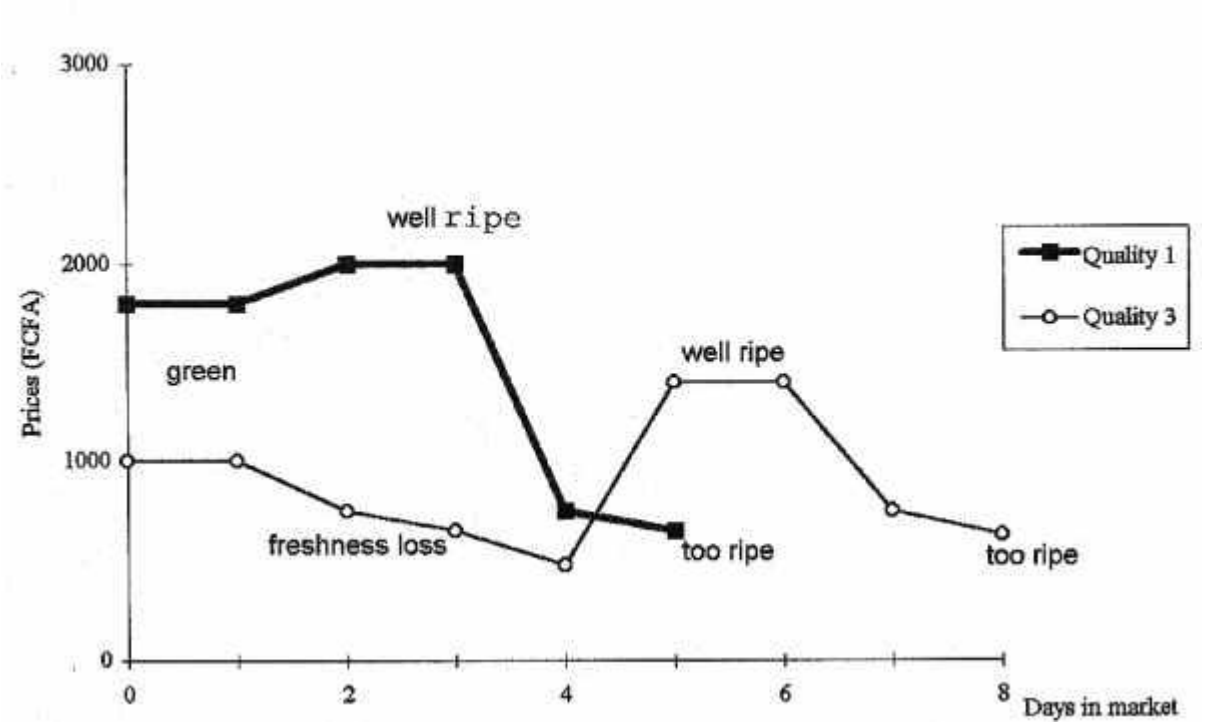


Figure 21: Evolution of the prices of two clusters (quality 1, quality 3) in accordance with their ripening stage (N'Da Adopo, 1996)

Whatever the process used the technology of keeping the unripened fruit allows the increase of price, and mobilises the capital of the seller without any guarantee of sales at a later time. Along the same lines, the cutting bunches and packaging them in boxes causes an unacceptable level of expenses. The final cost of the fruit becomes inaccessible for the typical consumer.

The informal sector is very developed in producing countries and all the range of small jobs result from practices found in the usual network.

The "loader" (See Figure 22) earns 10 FCFA per bunch loaded into the lorry (For example, 5000F CFA for 500 bunches placed in a lorry of 7 tons) (See Figure 17). After transport, the "identifier", who arranges the bunches during unloading in the main urban market, earns the same amount. Generally, the "identifier" prefers to remove one finger per bunch. He sells these fingers retail in the marketplace. The other packers also share 10 FCFA per bunch.

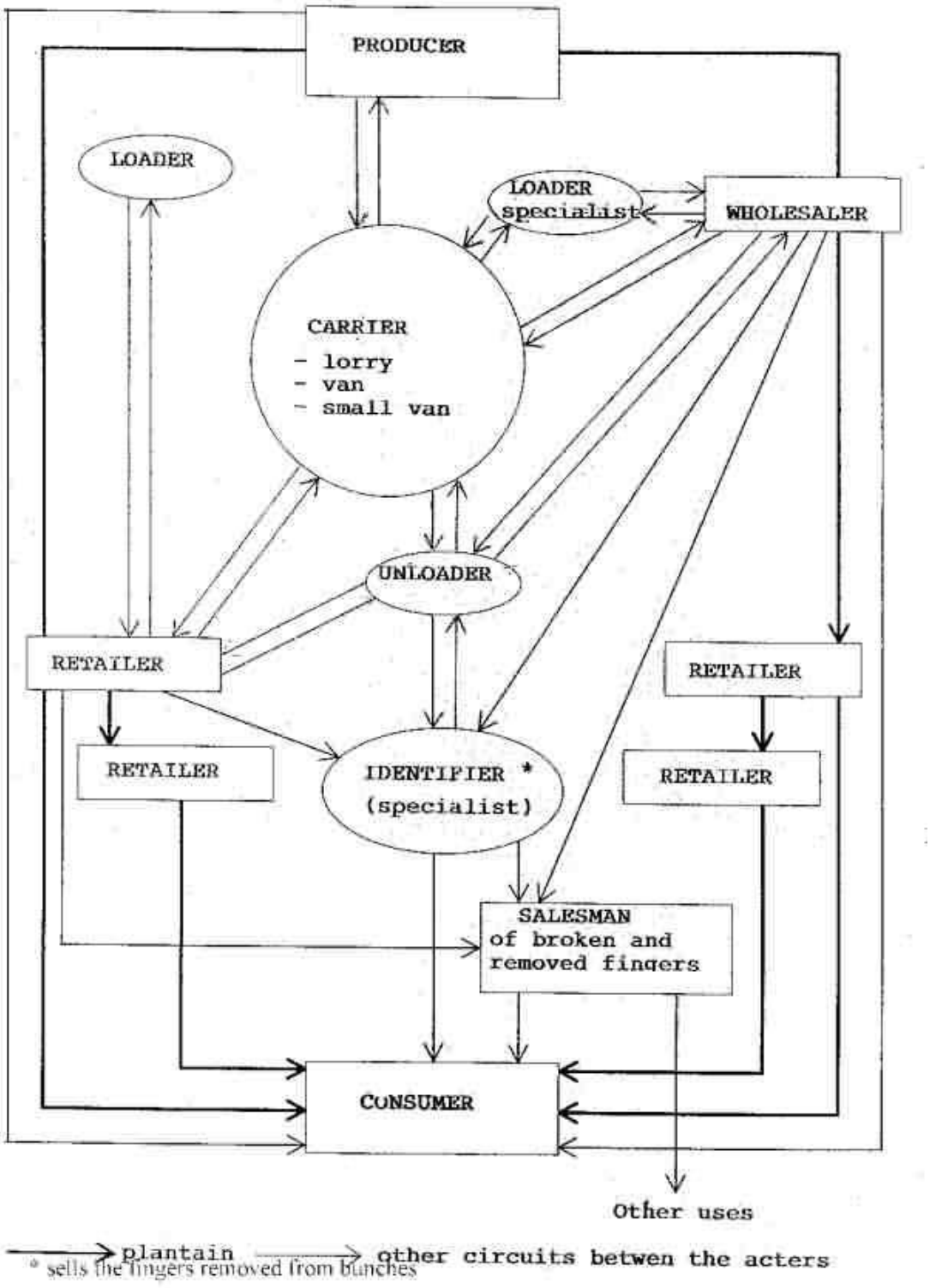


Figure 22: An example of the complex commercialization channel providing Douala (Cammeroon) with plantains (N'Da Adopo, Fruits, Vol. 48, no 2, 1993))

At a rate of two or three lorries per week or eight to twelve lorries per month, these auxiliaries can earn 60 to 80 000 F CFA per month. This amount represents an important income in these producer regions of developing countries. One or several broken or uprooted parts during the transportation of plantain is not very significant during the wholesale process. These broken parts are useful as they are sold once the lorry is unloaded. This enables the wholesaler to pay off some permanent fees:

- Pay the one who arranges fruits once in the lorry and other packers, recover fees of loading;
- Pay the diverse municipal taxes on the market;
- Amortise the cost of transportation of bunches.

The fingers broken during transportation represent rather additional earnings for the wholesaler rather than post-harvest losses. These fruits are distributed at sale prices, obviously advantageous to consumers who cannot buy the best plantains or unbroken fruits.

5.4 Improved techniques

The earnings of the participants can be improved by decreasing the numbers of bad clusters that are harvested. These mediocre qualities are the result of bad cultivation, poor soil and diseases. The solutions are the concern of agronomic training taking place in the farms and the fields.

Improved handling and storage conditions can reduce the high proportions of clusters, which are sold at a discount by those transporting plantain in particular, the intermediaries. It is recommended that:

PRACTISES OBSERVED	ACTORS CONCERNED	RECOMMENDATIONS
Non-Harvested Bunches Or Post-Harvest Losses In Field Or In Farm caused by : low prices due to excess bunches or intermediaries blackmails	Producers	favour exchange between the various actors by creating markets or collecting points in rural zones
		develop processing
very lean bunches due to poor soils, pests and cropping system		group the actors in co-operative
no vehicle to transport bunches to regional or urban markets		improve communication routes
no buyers		develop low price methods to improve cropping system
Rough Handling And Poor Storage Condition Meaning Decrease Of Value Of Bunches	Intermediaries	build shelters in the markets
	Producers Intermediaries consumers	Create an information network for plantain (quantities for sale by area, prices, qualities and export possibilities)
		make training on quality of foods

6. References

Ake Assi, L. (1985). Banana plantain: its use in traditional medicine in Côte d'Ivoire. *Proceedings of the 3rd meeting of IARPB. Abidjan, Côte d'Ivoire.* 27-31 May 1985. pp. 170.
Badia, I.A. (1985). Processing plantain chips in Honduras. *Proceedings of the 3rd meeting of IARPB. Abidjan, Côte d'Ivoire*, 27-31 May 1985. pp. 162-163.
Bustamente, M. (1983). Black Sigatoka effect on plantain production in Honduras. *Fruits*. Vol. 38, N° 4. pp. 330-332.
Champion, J. (1976). Bananas plantains and other cooking bananas up to date. Proceedings of a first work meeting in Ibadan. AGCD/IITA, 27 - 29 January. *Fruits.* Vol. 31, N° 9. pp. 495-516.
Chataigner, J. (1988). Socio-economic researches on the conditions of the production of banana plantain in West Africa. *Fruits*. Vol. 43, N° 1. pp. 25-28.
Cheftel, H. and Cheftel, J.C. (1980). Introduction to biochemical and technology of foods. Vol. 1, Chap. 23. Technique and documentation. *Edition of Modern Enterprise*. p. 163-166.
CODINORM. (1993). Bananas plantains. Norms in the Ivory Coast. *Specifications - NI 01-02-012.*
CRBP. (1994). *Le Courrier du CRBP*. N° 38. pp. 5.
Ddungu, J.C.M. (1985). The potential of cooking and other bananas in the cash economy of Uganda. *Proceedings of the 3rd meeting of IARPB. Abidjan, Côte d'Ivoire*. 27-31 May 1985. pp. 135-136.
Deullin, R. (1966). Test on banana at maturity. *Fruits*. Vol. 21, N° 4. pp. 186-188.
De Langhe, E. (1976). Why breeding of plantain is not feasible at present ? *Fruits*. Vol. 31, N° 9. pp. 537-539.
FAO. (1979). *Production Yearbook.* Vol. 33. Rome, Italy.
FAO. (1987). Strategies and requirements for improved production of roots, tuber and plantains. *Proceedings of Ninth session of Committee on Agriculture Item 9.* pp. 1-22.
Foure, E. (1985). Black Sigatoka on bananas and plantains in Gabon. Selection of new fungi molecules and behaviour of varieties. *Proceedings of the 3rd meeting of IARPB. Abidjan, Côte d'Ivoire*. 27-31 May 1985. pp. 72-85.
Ganry, J. (1978). Research of a method to estimate banana harvest according to climatic data in Antilles conditions. *Fruits*. Vol 33, N° 10. pp. 669-680.
Guillemot, J. (1976). Banana plantain in Côte d'Ivoire. *Fruits.* Vol. 31, N° 11. pp. 684-687.
IRFA. (1980). The quality of banana. *French norm and its application*.
Johnston, F. (1958). *The staple food economics of Western Tropical Africa*. Stanford University Press. Stanford, California, USA.
Kehe, M. (1985). The main insects attacking plantain in Côte d'Ivoire : importance of attacks and agro-economic consequences. *Proceedings of the 3rd meeting of IARPB. Abidjan, Côte d'Ivoire*. 27-31 May 1985. pp. 94-95.
Kiyingi, S.N. (1985). Uganda's women in plantain and banana: labour without compensation. *Proceedings of the 3rd meeting of IARPB. Abidjan, Côte d'Ivoire*. 27-31 May 1985. pp. 203-204.
Lassoudiere, A. (1978). Banana and its crop in Côte d'Ivoire. Vol. 1. pp. 2. IRFA.
Lescot, T. (1993). Banana plantain crop in Colombia and Andes countries. *Fruits*. *Special bananas II*. Vol. 48, N° 2. pp. 107-114.
Mihailov, S. (1986). Valorisation project of banana crop in Rwanda. Project TCP/RWA/4503 (A). *Proceedings of first mission*. pp. 38. FAO. Rome, Italy.

Mouliom Pefoura, A. (1985). Improving check system of Mycosphaerella fijiensis Morlet, Black Sigatoka agent on banana and plantains in Njombe (Cameroon). First results. *Proceedings of the 3rd meeting of IARPCB. Abidjan, Côte d'Ivoire*. 27-31 May 1985. pp. 86-87.
N'da Adopo, A., Temple, L. and Chantelot, E. (1992). Project of setting up a permanent observation system of banana plantain channel in Cameroon. CRBP. pp. 22.
N'da Adopo, A. (1992). Reducing post harvest losses of bananas plantains. *André Mayer Fellowship report*. pp. 119. FAO. Rome, Italy.
N'da Adopo, A. (1993). The channel and the quality of banana plantain in Côte d'Ivoire and Cameroon. *Fruits*. Vol. 48, N° 2. pp. 125-132.
N'da Adopo, A. (1996). Importance of harvest stage in the marketing of banana plantain in Cameroon. *Fruits*. Vol. 51. pp. 397-406.
Njoku, J.E. and Nweke, F.I. (1985). Plantain marketing in Southeastern Nigeria. *Proceedings of the 3rd meeting of IARPB. Abidjan, Côte d'Ivoire*. 27-31 May 1985. pp. 181-183.
N'Guessan, A., Yao, N. and Kehe, M. (1993). Banana plantain crop in Côte d'Ivoire. *Fruits. Special bananas II.* Vol. 48, N° 2. pp. 133-143.
Osafo, D.M. (1986). Sources of photosynthate for fruit filling in plantain. *Proceedings of Annual Meeting of WARCORP.* Mbanza Ngungu, Zaire, 2-6 December 1986. pp. 5.
Rowe, P.R. (1976). Genetic possibilities for improving plantain yield. *Fruits*. Vol. 31, N° 9. pp. 531-536.
Sery, D.G. (1985). Study of different plantain cropping systems in Côte d'Ivoire. *Proceedings of the 3rd meeting of IARPB. Abidjan, Côte d'Ivoire*. 27-31 May 1985. pp. 126-134.
Sery, D.G. (1988). Economic role of banana plantain in Côte d'Ivoire. *Fruits*. Vol. 43, N° 2. pp. 73-78.
Simmonds, N.W. (1959). *Bananas*. pp. 44-65, 205-333. Longmans, ed.
Stover, R.H. (1985). Biomass production, partitioning and yield determinants in bananas and plantains. *Proceedings of the 3rd meeting of IARPCB. Abidjan, Côte d'Ivoire*. 27-31 May 1985. pp. 40-41.
Temple, L., Genettais, T., Ganry, J., and Chataigner, J. (1993). Plantain production systems and intensification prospects in Southwest Cameroon. Fruits. Special bananas II. Vol 48, N° 2. pp. 119-123.
Tlu, Ira-Ekona. (1987). Farming systems surveys in South-West district (Cameroon) in Meme, Fako, Manyu and Ndian divisions.
Wilson, G.F. (1983). Plantains production: prospects for improving the food situation in the tropics. Fruits. Vol. 38, N° 4. pp. 229-239.