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Plantain (*Musa paradisiaca* L.): Production, Consumption and Processing in Cameroon

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Abstract Plantain (*Musa paradisiaca* L.) is a herbaceous plant of the Musaceae family, native to Southeast Asia and cultivated in most localities in Cameroon. Agricultural products such as potato, cassava, yam and plantain are processed into many products and are an alternative to wheat flour in developing countries. The objective of this study is to promote the production and processing of plantain. The vegetative cycle of the plantain varies between 10-18 months depending on the variety, its consumption is 150 kg/inhabitant/year and has 35.5 g of carbohydrates; 1.3 g of proteins and 5.8 g of fibers. Regular consumption of plantain can be an effective way to fight against oxidative stress. However, it has medical and therapeutic value for diabetic patients, gallbladder disease and colon cancer. Gastrointestinal disorders like diarrhea and vomiting can be treated with plantain. It is processed in developing countries to formulate food products like cake, doughnut, pancake, jam and many others. This study contributes to reduce post-harvest losses of plantains and to fight against food insecurity in the world especially in Cameroon.

Keywords: *plantain, production, nutritional composition, medical value, derived products*

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1. Introduction

Plantain (*Musa paradisiaca* L.) is one of the most important food crops widely produced and consumed in sub-Saharan Africa [1]. In Cameroon, where production is about 3 million tons per year [2], plantain occupies a predominant place in households and plays an important role in the food security of the population [3]. In this respect, the consumption of plantain has been estimated at 150 kg/capita/year in Cameroon [4]. Regarding the nutrient content, it has been reported that 100 g of plantain contain about 35.5 g of carbohydrates, 1.3 g of protein, 0.3 g of fat and 5.8 g of fiber and provide 122 kcal [5]. In addition, mature plantain contains many bioactive molecules, including carotenoids (4680 µg/100 g), vitamin C (11.7 mg/100 g), minerals, and phenolic compounds. Thus, its regular consumption may be an effective way to fight against oxidative stress [6,7], which may be the cause of many chronic diseases, such as some cancers, diabetes, cardiovascular diseases, renal, neurological and chronic respiratory diseases [8]. Despite this nutritional importance and the bioactive potential of plantain, its use is limited by post-harvest losses of more than 20 to 40% in Cameroon [2]. Indeed, after harvesting, ripe green fruits undergo rapid ripening resulting in the appearance of black spots on the surface of their skin 10 to 12 days later. Beyond this stage of ripening, it loses its technological properties and even its market value [9].

There is no real method of preservation or transformation into finished or semi-finished products that would allow long-term storage of plantain [10]. In rural areas, plantain pulp is often dried in the sun and consumed as a delicacy, but there is no provision for long-term storage of this product. This dried pulp, very rich in sugars, rehydrates quickly if not packaged and the development of yeasts and molds leads to rotting which makes it unfit for consumption. Studies for the transformation of plantain into improved traditional products are underway and will eventually lead to the development of stabilized flours. Studies have made it possible to partially substitute wheat flour with non-bread flours (rice, cassava, legumes, etc.) to make cakes [11-16]. These different studies have shown that it is possible to substitute wheat flour up to 50%, with other products, to obtain cakes with similar characteristics to those prepared with 100% wheat flour. Plantain cakes exist, but are not well known. Some work has shown that bread and cookies can be made by substituting wheat flour with plantain flour [17]. Formulations using between 20 and 40% plantain flour for bread and cookies, respectively, yielded acceptable products. The aim of this study is to reduce post-harvest losses of plantain fruits among farmers and to promote plantain flour-based food products at the local level.

2. Biology and Ecology

Plantain is native to Southeast Asia, where it is found from India to Polynesia [18] and its center of diversification seems to be Malaysia or Indonesia [19]. It spread to West Africa at least 2500 years ago [19]. For thousands of years, human migrations and exchange of plant material have introduced banana in very different ecological situations on all continents [20]. Banana plants belong to the order Scitaminales, or Zingiberales, and to the family Musaceae. They are monocotyledons with floral parts in threes or multiples of three, asymmetrical zygomorphic with secondary venation of the parallel blades with an absence of secondary vascular formation in the stem and roots. The family Musaceae has three genera, namely: Musella, which is very little represented and localized in Asia, Ensete, which has no parthenocarpic species, and Musa, which has a high variability and is characterized by inflorescences with bracts inserted separately from the flowers, unlike the genus Ensete.

2.1. Description of the Plantain

Plantain (*Musa paradisiaca* L.) is a tropical herbaceous perennial monocot plant. The underground part of the banana plant is composed of a bulb or true stem, provided with numerous adventitious roots which appear successively during its development. The terminal meristem of the stem produces a series of 20 to 30 leaves of increasing size every 6 to 15 days according to the conditions of temperature, hydrometry and insolation. The number of leaves thus varies according to the cultivar and environmental conditions [21]. Plantain is a berry containing seeds with a reduced pulp. The cycle length is about 10 to 18 months depending on ecological conditions and cultivars. The description of the banana plant, in general, has been made by several authors [22-28]. The following Figure 2 illustrates the botanical description of banana.

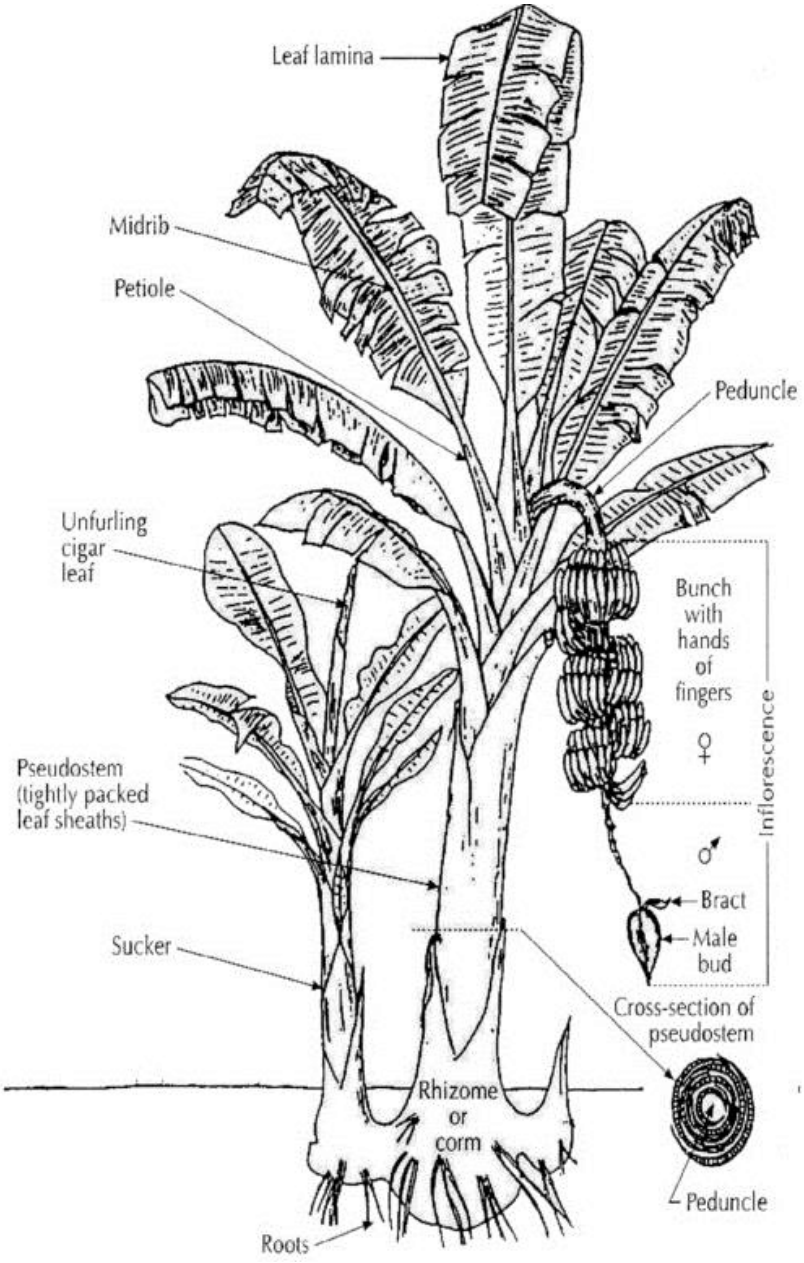


Figure 1. Botanical description of banana (Ludivine *et al*., 2009)

3. Plantain Production

3.1. Edaphic Factors

The cultivation of plantain requires a pH that varies between 5.5 and 6.5. A good texture and structure that is to say a good balance between clay, silt, sand, organic matter and structure that must be lumpy and of good porosity [31]. This is why forest soils are favorable for banana cultivation [32]. The defects for the culture are the lack of manure, the bad drainage, the compactness of the soil. However, soils with a hardened or gravelly horizon and a too shallow water table are unsuitable for banana cultivation.

3.2. Nutrient Requirements

Plantain requires large amounts of nitrogen, potassium, phosphorus, calcium and magnesium. In addition to the ecological and environmental problems that it causes, mineral fertilization alone does not make it possible to maintain soil fertility. Its exclusive use leads to an increase in acidity, a degradation of the physical status and a decrease in soil organic matter [33]. In addition, their production and transport contribute to the emission of greenhouse gases [34]. In such a context, organic fertilization could be an appropriate solution for restoring soil fertility and improving plantain productivity. Organic farming practices aim to increase biodiversity and biological activity of soils. In this way, they help to achieve optimal natural systems that are socially, ecologically and economically sustainable [35]. Numerous studies have shown that plant residues and organic manures such as chicken droppings, which are by-products of animal husbandry, contribute to plant growth through their beneficial effects on the physical, chemical and biological properties of soils [36]. The periodic replenishment of soil reserves in these elements to maintain good crop productivity is thus essential [37]. Given its availability in urban areas, dried and ground plantain peel, used alone or mixed with chicken manure compost, could be an alternative to the use of mineral fertilizers [38].

3.3. Harvesting, Storage and Preservation

Fruit ripening is characterized by a set of biochemical and physiological changes leading to the state of ripeness and giving the fruit its organoleptic characteristics [39]. Under normal conditions of ambient temperature (30°C), plantain ripens between 5 and 9 days after harvest, if physiological maturity is reached. This time interval is reduced by faulty storage and lack of care during various post-harvest handling (transport, market display, etc.) [40,41]. There is no real preservation method for long-term storage of plantain [10]. Even in periods of high production, plantain bunches do not wait more than 3 to 4 days before being marketed [42,43]. Losses therefore occur at the production site, due to the lack of preservation or evacuation of the products to the marketing centers. The use of polyethylene bags is a simple way to achieve controlled atmospheres [44]. Studies on the effect of polyethylene packaging on the preservation of plantain at 4°C, 12°C and 25°C, have been able to maintain green plantain for 20 days between 12 and 25°C; but preservation beyond this time is detrimental to the quality of the fruit [45]. The use of polyethylene bags can create a CO2-rich, O2-poor microenvironment in the storage medium that delays ripening [46,47,48]. Polyethylene bags of 100 µm thickness can preserve plantain at room temperature after treatment with gibberellic acid or imazalil sulfate [49].

Plantain is a highly perishable fruit, with post-harvest losses of 30-40% [50]. Methods to extend fruit shelf life include harvesting bunches a few days before they reach full maturity, storage at reduced temperatures (about 15°C), storage in a modified atmosphere of enriched CO2 at low O2 (3-4%), packaging in film bags to prevent weight loss, pretreatment with fungicides, and skin coating [51]. For cultivars sensitive to high levels of CO2, an alternative storage method is vacuum packing [52]. Figure 2 shows a mature plantain diet.

Figure 2. Mature plantain diet (Ngoh *et al.*, 2017)

4. Nutritional Importance, Medical and Therapeutic Value of Plantain

4.1. Nutritional Importance of Plantain

Plantain is used as a cheap source of calories [53]. It is one of the most important sources of food energy in West and Central Africa, where about 70 million people obtain more than 25% of their carbohydrates from plantains [54,55]. Plantain is an “indigenous” product used in many culinary preparations [56]. Consumption of this product is often linked to important events in the life of Cameroonian families: weddings, funerals, reunions and festivals. In some cases, the presence of a specific plantain dish is even mandatory [57].

Plantain is an energy food that provides 120 kcal or 497 kJ per 100 g of fresh material, contributing about 70%

of the food energy supply provided by plantains and cooking bananas in the world [58].

Plantain is consumed in several forms: boiled, grilled, fried, kneaded, sautéed, braised and mashed [59]. The plantain is consumed raw but very often cooked. It is ubiquitous in African cuisine in its natural state, roasted, stewed, mashed, crisped, or even in the form of beer. In Cameroon, the plantain is one of the most consumed starchy foods. It is a basic product of income and self-consumption, which often accompanies meat and fish for which it serves as a complement. In addition, it is known as a snack product, together with rice, because of the speed with which it is cooked compared to other starchy foods [60]. Table 1 presents the nutritional composition of 100 g of plantain.

Table 1. Nutritional composition of 100 g of fresh plantain (ANSES, 2020)

Nutrients	Content per 100 g
Protein	1.28 g
Carbohydrates	29.6 g
Lipids	0.39 g
Vitamins	
Beta-carotene	457 µg
Vitamin E	0.14 mg
Vitamin K1	0.7 µg
Vitamin C	18.4 mg
Vitamin B1	0.052 mg
Vitamin B2	0.054 mg
Vitamin B3	0.69 mg
Vitamin B5	0.26 mg
Vitamin B6	0.3 mg
Vitamin B9	22 µg
Minerals	
Calcium	3 mg
Copper	0.081 mg
Iron	0.6 mg
Iodine	2.5 µg
Magnesium	37 mg
Phosphorus	34 mg
Potassium	499 mg
Sodium	4 mg
Zinc	0.14 mg

4.2. Medical and Therapeutic Value

Eating a banana can help digestion because of its high vitamin A content. Gastro-intestinal disorders like diarrhea and vomiting can be treated with plantain. Studies conducted suggest that plantain diet is good for diabetic patients, those with gallbladder disease and colon cancer [61]. Its sodium level is low and therefore it is recommended in the formulation of low sodium diet.

In the green stage, the liquefied fruit is used in Brazil to treat dehydration in infants, as its tannins tend to protect the lining of the intestinal tract from further fluid loss [62]. In general, plantains are suitable for consumption when a low-fat, low-sodium, and/or cholesterol-free diet is required, making plantains particularly recommended for people with cardiovascular or kidney problems, arthritis, gout, or gastrointestinal ulcers [63].

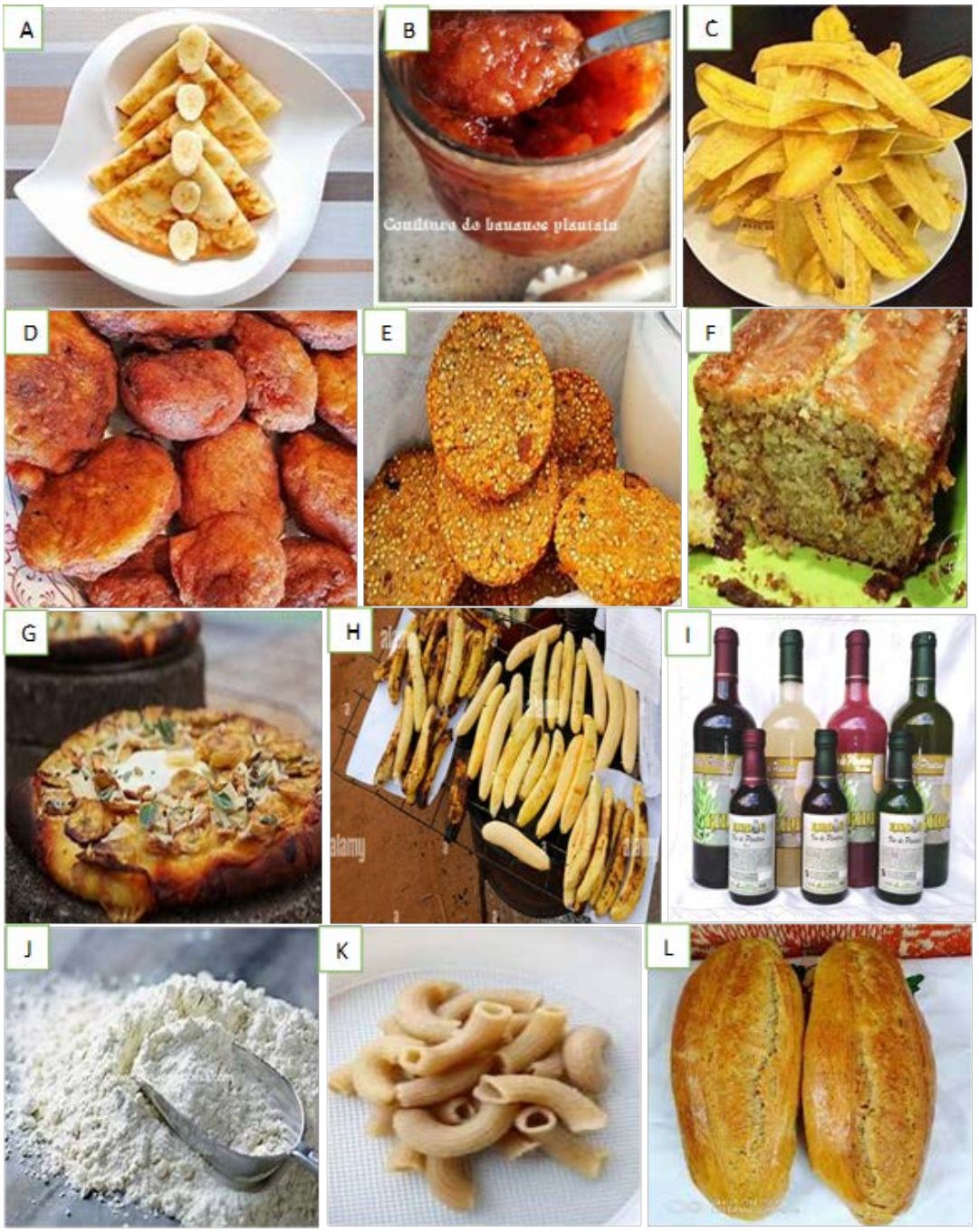
Bananas and plantains contain complex carbohydrates capable of replacing glycogen as well as important vitamins (especially B6 and C) and minerals (potassium, calcium, magnesium, iron) [64]. Some varieties are very rich in provitamin A [65]. Ripe fruits have been used to treat asthma and bronchitis. Boiled and crushed ripe fruits (especially mixed with other plant substances) are cited as a good remedy for constipation.

These many purported remedies are not well documented and would require further investigation [66]. Banana pseudotrunc is cooked in India as a khich khach dish, taken monthly to prevent constipation [67]. The juice extracted from the male bud is considered good for the stomach. The fresh leaves have been used medicinally for a range of ailments from headaches to urinary tract infections, and the stem juice was considered a remedy for gonorrhea. The peel of ripe bananas has antiseptic properties and can be used to prepare a poultice for wounds or applied directly in an emergency [68].

5. Food Products Derived from Plantain

Some people cannot tolerate gluten from wheat and other grains such as oats, rye and barley because it causes celiac disease. It severely impairs intestinal absorption and can lead to severe malnutrition [69,70]. Therefore, research efforts in tropical countries are currently aimed at identifying non-wheat sources that could be used as an alternative to wheat flours, thus affecting the foreign exchange economy by limiting wheat imports. These non-wheat flours are obtained from other cereals, legumes, tubers and roots, for example maize, rice, soybean, sorghum, cassava, sweet potato, potato and plantain [71,72]. Plantain processing creates significant added value for stakeholders. However, the agro-industrial development of plantain processing is embryonic. The main processing products currently known are: chips, baby food, cossettes, flours from green pulp (unsweetened flour) and ripe pulp (sweetened flour), standardized fries, braised ripe plantain, dried ripe pulp, frozen pulp [73]. They also involve small and medium-sized artisanal enterprises specializing in reconstituted products for local dishes (ntouba, foutou, etc.), pancakes made from plantain flour, the manufacture of bread, cakes, doughnuts and various bakery products entirely or partially formulated from plantain flour [74,75]. Among these processed products, the products most encountered on Cameroonian markets remain chips, braised plantains and sold in the streets of large urban areas [76,77]. However, plantain is gradually finding applications in the formulation of weaning foods and compound meal preparations [17,78]. Banana beer is reserved for celebrations and other events marking social life [79,80,81]. Fermented banana drinks, usually called banana wines, can also be prepared. Fermentation takes place in the open air and lasts about 3 days [82,83,84].

Cakes, breads and cookies are made using 100% plantain flour have yielded acceptable products [17]. Plantain fritters are also obtained from the pulp of ripe plantains pounded and mixed with a small amount of wheat or other local cereal flour (about 1/4 of the weight of the dough) and salted to form a homogeneous paste [85]. Pancakes made from 100% plantain flour and jam made from a plantain hybrid, spaghetti have been popular with consumers [86,87,88]. Figure 3 below shows some food products derived from plantain.



A=pancakes; B=jam; C=chips; D=doughnuts; E=biscuits; F=cake; G=pizza; H=roasted plantain; I=plantain wine; J=plantain flour; K=macaroni; L=bread.

Figure 3. Some products derived from plantain

6. Conclusion

The cultivation of plantain is favorable when the temperature is between 25-30°C, a pH that varies between 5.5 and 6.5. Plantain requires a large amount of nitrogen, potassium, phosphorus, calcium and magnesium. Its theoretical yield is 30t/ha when the soil is rich in nutrients and its vegetative cycle varies from 10-18 months depending on the variety. Plantain is an energy food that provide 120 kcal or 497 kJ per 100 g of fresh material, contributing about 70% of the food energy supply provided by plantains and cooking bananas in the world.

Plantain is consumed in several forms: boiled, grilled, fried, kneaded, sautéed, braised and mashed. Regular consumption of plantain is effective in fighting oxidative stress which can lead to many diseases such as cancer, diabetes, kidney disease, neurological and chronic respiratory diseases. However, after the ripening of the plantain a period of a few days is enough to cause its degradation hence the implementation of processes to reduce post-harvest losses. The diversification of the use of plantain can help to promote a large use of this product. Thus, the production of plantain derivatives allows today to valorize plantain pulps. The use of plantain flour in the agri-food sector allows the design of quality products that contribute to the fight against food insecurity in developing countries.

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