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Plantain (*Musa spp*., AAB genome) Cultivar Preference, Local Processing Techniques and Consumption Patterns of Plantain Based Foods Mostly Consumed in Urban Area of Abidjan, Côte d'Ivoire

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Abstract

This survey aimed at identifying the plantain consumption patterns based on the most preferred plantain cultivars according to the maturity and the processing in the urban area of Abidjan, Côte d'Ivoire. Thus, a Focus Group has been led to appreciate the availability of plantain on market and Data Mining techniques have been used for the treatment of data collected from household interviews. Data showed that only four cultivars of plantain locally named *Kpatregnon*, *Ameletiha*, *Agnrin* and *Afoto* are available on the markets of Abidjan. *Afoto* cultivar is the most available in quantity. *Ameletiha* variety at maturity stages full yellow with black spots (stage 7) and half green, half yellow (stage 3) are the most preferred by consumers. And, the physical parameters such as the shape of the fingers, the size of fingers and the aspect of plantain fingers are not important in consumer's choice. It also appears that the *Agnrin* variety at the stages full yellow (stage 6) and full yellow with black spots (stage 7) is the most used for *aloko*. As for the *Afoto* variety, stage of maturity light green (stage 2), it is the most used to make roasted plantain (banane braisée). The *Ameletiha* variety at the green maturity stage (stage 1) and all black (stage 8) is the most used to do chips and *doclou*, respectively. *Ameletiha* and *Agnrin* varieties at the stage of maturity half green, half yellow (stage 3) and more yellow than green (stage 4) are both appreciated for *futu* (pounded banana). *Ameletiha* variety of maturity stage 8 (all black) is preferably used for the *klaclo*. According to variety and maturity, plantain is used in several food preparations of which eleven are the mostly preferred by consumers in Abidjan area.

Keywords: Plantain; Preference; Cooking; Variety; Maturity; Focus group; Household interview; Abidjan urban area.

Résumé

Cette enquête vise à identifier les modes de consommation de la banane plantain sur la base de variétés les plus appréciés en fonction de la maturité du fruit et de sa transformation en milieu urbain à Abidjan, Côte d'Ivoire. Ainsi, un Focus Group a été mené afin d'apprécier la disponibilité du plantain sur le marché et des techniques d'exploration de données (*Data mining*) ont été utilisées pour le traitement des données recueillies lors des entretiens dans les ménages. Les données ont montré que quatre variétés de plantain nommées localement *Kpatregnon*, *Ameletiha*, *Agnrin* et *Afoto* sont disponibles sur les marchés d'Abidjan. La variété *Afoto* est la plus disponible en volume de production. La variété *Ameletiha* à maturité jaune avec des taches noires (stade 7) et tournant vert (stade 3) sont les plus appréciés des consommateurs. Les paramètres physiques tels que la forme des doigts, la taille des doigts et l'aspect des doigts du plantain ne sont pas importants dans le choix du consommateur. La variété *Agnrin* au stade jaune de maturité (stade 6) et jaune avec des taches noires (stade 7) est la plus utilisée pour l'*Aloko*. Quant à la variété *Afoto* au stade de maturité vert clair (stade 2), elle est la plus utilisée pour faire la banane braisée. La variété *Ameletiha* au stade de maturité vert mature (stade 1) et toute noire (stade 8) est la plus utilisée pour faire respectivement le chips et le *doclou***.** Les variétés *Amélétiha* et *Agnrin* aux stades de maturité tournant vert et tournant jaune sont toutes deux appréciées pour faire le foutou. La variété *Ameletiha* au stade 8 de maturité (toute noire) est utilisée de préférence pour faire le *klaclo*. Selon la variété et la maturité du fruit, le plantain est utilisé dans plusieurs préparations alimentaires dont onze (11) sont préférées par les consommateurs à Abidjan.

Mots clés: Plantain; Préférence; Cuisson; Varieté; Maturité; Focus group; Entretien dans les ménages; Milieu urbain d'Abidjan**.**

1. Introduction

Plantain (Musa AAB) is one of the most important food crops in tropical regions of the world and a staple source of carbohydrates energy for human consumption. FAO [1] data sources estimates the world production of plantains at about 60 million tons. In 2011, 12.46 million metric tons (12.46.000.000 MT) of plantains were produced in West Africa, representing 32.0 % of worldwide production according to FAOSTAT [2]. This production increased from an average annual rate of 2.3% to 2.6% [1]. Plantains constitute a major staple food crop for people, as well as a valued source of income through local and international trade [3]. In addition to being a cheap and an easy source of energy, mature plantains pulp are also rich in vitamins A, C, B6, minerals (Mg, K, Ca, P…) and dietary fibre [4] but their composition varies according to the species and the variety as well as the maturation [5]. Several food consumption surveys in Côte d'Ivoire identified plantain among the major starchy staples and an important traditional staple food [6] [7] [8] [9] [10]. Traditionally produced in forest zone of Côte d'Ivoire, plantain is a dynamic staple food. Its consumption increases regularly in various forms, and has been extended to the whole Ivorian people, both in rural and urban areas [11]. It ranks third (1,500 000 tons/year) among the most consumed food after yams (3,000 000 tons/year) and cassava (1,700 000 tons/year) [12] for a consumption estimated at 120 kg/capita/year [13]. The majority of cultivated plantains is triploid varieties (ABB group) belonging to the Eumusa section of the genus Musa, family Musaceae [14]. They are constituted of many cultivars (*M'bomo, Lorougnon, Nselouka, Diby 2 off-type, Madre del Platanar, Niangafelo, Bungaoisan, Didiede, French Clair, Diby* [15] varying in shape, size, color and taste, etc. Plantain-banana, which can also be referred to as cooking-banana, is consumed necessarily cooked according to the desired use, at various stages of maturation, classified from stage 1, green skin, to stage 7, yellow skin with black spots [16]. The banana trees fruits after harvest undergo a process of maturation and senescence. Internal fruit chemical composition changes dramatically during plantain fruit ripening. The major classes of cell wall polysaccharides that undergo modifications during ripening are starch, pectins, cellulose and hemicelluloses. These modifications are allotted to the action of enzymes. Thus, the starch will progressively be converted to sugar as ripening progresses [16]. In Côte d'Ivoire, there are many food uses of plantain relative to eating habits of consumers. The fruits of plantain are generally subject to post-harvest culinary process~~es~~ that take into account the varietal aspect, the maturity, the cooking method, the method of processing and the addition of other foodstuffs. Previous study on consumption pattern reported that plantains are consumed in different forms including boiling, roasting, frying, as well as in combination with other staples [17] [18] [19] [8]. Although plantain is of undisputed importance in the diet of both rural and urban populations, and despite its related marketing activities, there is no clear pattern in the consumption of plantain at the household level in urban areas. Consequently, there has been limited research and hardly any documentation on the preferences for the various plantain cultivars grown, their processing/cooking techniques and consumption patterns among households. Therefore, this study aimed at identifying the plantain consumption patterns based on the most preferred plantain cultivars according to the maturity and the processing in the urban area of Abidjan, Côte d'Ivoire.

2. Methodology

2.1. Area Of Study

The survey was conducted on the markets and the households of five (5) urban councils of Abidjan, the economical capital city of Côte d'Ivoire, using focus group discussion (FGD) and household interviews (HHIs) respectively during the month of November 2012. Abobo, Cocody, Adjamé, Yopougon and Treichville urban councils were selected based on the high intensity of plantain consumption [20]. Also, the food consumption habit in Abidjan is representative of the food consumption habit in the whole country [21] [22].

2.2. Focus Group

Semi-structured open-ended questions were developed and used for key informant's interview. The collection of data consisted in comparing the different views of women surveyed to bring out a consensus on plantain varieties available on the market. In each market of the urban councils, the panel is composed of 10 women whose daily job is the selling of plantain. Women were selected according to two (2) criteria or profiles, the seniority and the regularity in plantain trade. Panelists were three (3) wholesalers, three (3) semi-wholesalers and four (4) retailers.

2.3. Consumption Pattern And Selection Of Respondents

Data on consumption pattern were obtained by self-administered questionnaire on five hundred (500) households who know, consume and use plantain regularly. One hundred (100) households were chosen per urban councils using the snowballs method. Only the head of household were interviewed to identify dishes commonly consumed due to both plantain variety and its maturation stage as classified by Boudhrioua et al. [23]. We asked the heads of household to give dishes according to their first and second preference. The survey form which can provide all the information on the food has been prepared using the Sphinx Millenium software.

2.4. Data Analysis

Data were subject to three (3) types of treatment by Data Mining techniques. First, strip charts were constructed to get the different distribution of variables. Then, a multiple correspondence analysis (MCA) was needed to understand the interactions between terms of different variables. Thereafter, the technique of decision trees was used to identify the criteria on which consumers rely to buy plantain. Finally, an alternative step decision tree was used to predict the most appropriate varieties of plantain for an particular use and a given maturity. Analyses were performed using the software Open Source of Data Mining R (2.9.0) and Orange (2.6.a2) (R Core Team, 2012).

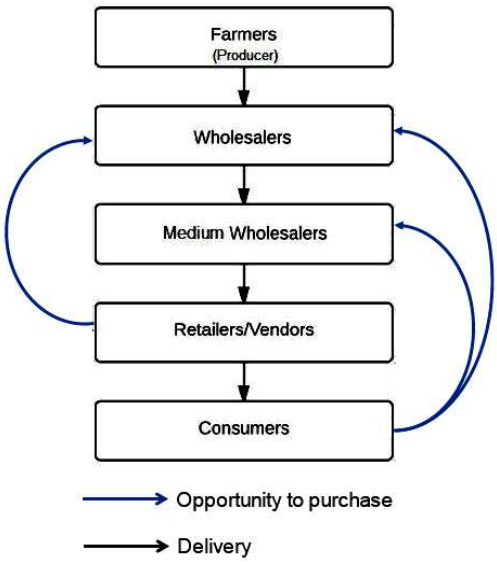

Fig. 1: Marketing channels and distribution for plantains in Abidjan (Côte d'Ivoire)

3. Results

3.1. Popular Plantain Cultivars And Marketing System

Data of Focus Group Discussion (FGD) showed that four (4) plantain marketing channels appear in plantain distribution: (1) producers to consumers through wholesalers, medium wholesaler and retailer, (2) consumer to wholesaler, (3) consumer to medium wholesaler and finally (4) retailer to wholesaler (Figure 1).

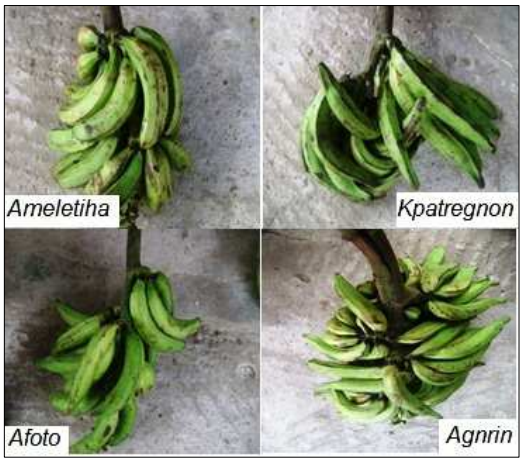

Fig. 2: Popular plantain cultivars (*Musa spp*., AAB genome) in Côte d'Ivoire

Four (4) varieties of plantain: *Kpatregnon*, *Ameletiha*, *Agnrin* and *Afoto* (Figure 2) are released twice a week. *Afoto*, *Agnrin*, *Ameletiha* and *Kpatregnon* varieties are respectively the most important in volume of production and in availability. These varieties of plantain have many synonym and they differ in shape (diameter) and size (length) of the fingers, and secondarily in the appearance (angularity) of the fingers. For example, *Afoto* variety has a big finger with an average size; *Agnrin* has many hands and fingers small sizes. *Kpatregnon* variety has very long and thick fingers with two hands on generally regime. As for the variety *Ameletiha*, the fingers are medium and without floral piece (Table 1).

3.2. Cultural Preference Variety Of Plantain

According to ripening stage, the preference of plantains differs from one cultivar to another (Figure 3). Indeed, *Ameletiha* is the most preferred cultivar, followed by *Agnrin*, *Afoto* and *Kpatregnon* respectively. The preference of *Ameletiha* is more pronounced at ripening stage 7 (full yellow with black spots) and at ripening stage 3 (half green, half yellow). *Agnrin* is the most preferred cultivar at ripening stage 4 (more yellow than green stage); *Afoto* is most preferred at ripening stage 2 (light green). *Kpatregnon* is most preferred at stage 3 (half green, half yellow).

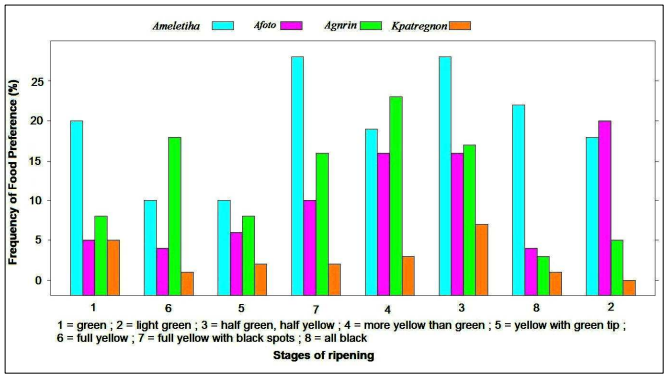

Fig. 3: Overall preference of plantain varieties according to ripeness stage

Table 1.
Description and botanic characteristics used in identification of the four most popular cultivars merchandised in Abidjan, Côte d'Ivoire

Local name	Synonyms	Genomic group	Sub-group	Characteristic used to identify the cultivar		
				Cycle (month)	Fruit	Botanic character
Kpatregnon (Kpatré n'gnon)	*Assamié g'nouan*	AAB	Plantain (Horn)	8 - 25	Very long and large, Fruits > 25 cm, almost straight	True Horn
Ameletiha (M'létia)	*Assamara*	AAB	Plantain (French)	15 - 18	Fruits slender, medium height, compact appearance	French
Agnrin (Agnirin)	-	AAB	Plantain (French)	15 - 18	Short 15 cm, almost perpendicular to rachis, compact appearance	French Horn
Afoto	-	AAB	Plantain (Horn)	10 - 12	Sharp curved long fruit, Fruits > 25 cm, almost straight	False Horn

3.3. Popular Cooking And Processing Methods Of The Preferred Plantain Cultivars

It was established that the main processing techniques applied to plantain selected uses three different methods: boiling, roasting and frying. The boiling and pounding method is conducted by peeling, and boiling unripe or ripe plantain (10 kg) for 30 minutes in 5 L of water. The water is then drained and the boiled plantain transferred into a wooden mortar to be pounded until obtaining a smooth consistent paste. Fried plantain are generally prepared by peeling and deeply frying in 2 L of preheated oil for 1 kg of plantain during 20 min, with only the addition of salt, until golden yellow/brown color is obtained. Concerning roasting method, 250 g of unripe plantain fingers are peeled, placed on wire gauze over a red-hot charcoal stove and roasted for 30 min with frequent turning to prevent the plantain from charring. When the plantain is brown evenly, the plantain is removed and served to consumers.

3.4. Overall Preference Of Plantain Cultivars According To The Ripeness And Food Uses

According to food uses, *Agnrin* at ripening stage 6 (full yellow) and stage 7 (full yellow with black spots) stages, are most commonly used to make *aloko*. Incidentally, *Ameletiha* and *Afoto* at ripening stage full yellow with black spots stage (stage 7) also used to make *aloko* (Figure 4A). To make chips, it's *Ameletiha* at green ripening stage (stage 1), which is the most used (Figure 4B). *Ameletiha* at ripeness all black (stage 8) is more used to the *doclou* (Figure 4C). Only *Ameletiha* at ripening stages 7 (full yellow with black spots) and 8 (all black) is preferably used for the *klaclo* (Figure 4D). For the bananas cooked on grill (roasted plantain), *Afoto* at ripening stage light green maturity (stage 2) is the most used, followed by *Ameletiha* at the same stage (Figure 4E). Apart from *Kpatregnon*, all other plantain cultivars at ripening stages 3 and 4 are valued for *futu* with *Ameletiha* and *Agnrin* by importance order at ripening stage 3 (half green, half yellow); *Agnrin* and *Ameletiha* by importance order at ripening stage 4 (more yellow than green) respectively (Figure 4F).

3.5. Overall Preference Of Plantain Varieties Depending On Ripeness, The Food Use And Physical Characteristics

Data showed that maturity is generally decisive in the choice of the use of the banana on cooking (Figure 6 a, b). The absence of fruit characteristics (size, appearance, shape) showed that they have no significant influence on consumer choice. That is the case of *Kpatregnon* which can be used for *futu* (pounded plantain) regardless of the maturity stage and the characteristic of the fruit (Figure 5). However, *klaclo* can be made with short size fruit of *Afoto* and *Ameletiha* varieties. Also, data confirmed that

the *doclou* is made with plantain at ripening stage all black (stage 8); *aloko* with *Agnrin* variety; roasted plantain at ripening stage half green, half yellow stage (stage 3) (Figure 5).

3.6. Consumer Preferences Of Foods Based On Plantain

According to modeling (the decision trees), for the first choice of consumers, the *futu* is prepared at maturity stages half green, half yellow (stage 3); yellow with green tip (stage 5) and more yellow than green (stage 4) (Figure 6a). *Aloko* is made with plantain at full yellow (stage 6) and full yellow with black spots (stage 7) stages of maturity. *Klaclo*, rosted plantain (*banane braisée*) and chips are made with plantains at maturity stages all black (stage 8), light green (stage 2) and green (stage 1) respectively (Figure 6b). Following their second choice, *doclou* is made with banana at maturity stage all black (stage 8), *futu* is made with plantain at the stages of maturity green (stage 1) and light green (stage 2 Thus, according to consumer preference (1^{st} and 2^{nd} choices), eleven (11) food preparations of plantain were identified (Figure 6). Their characteristics are showed in Table 2.

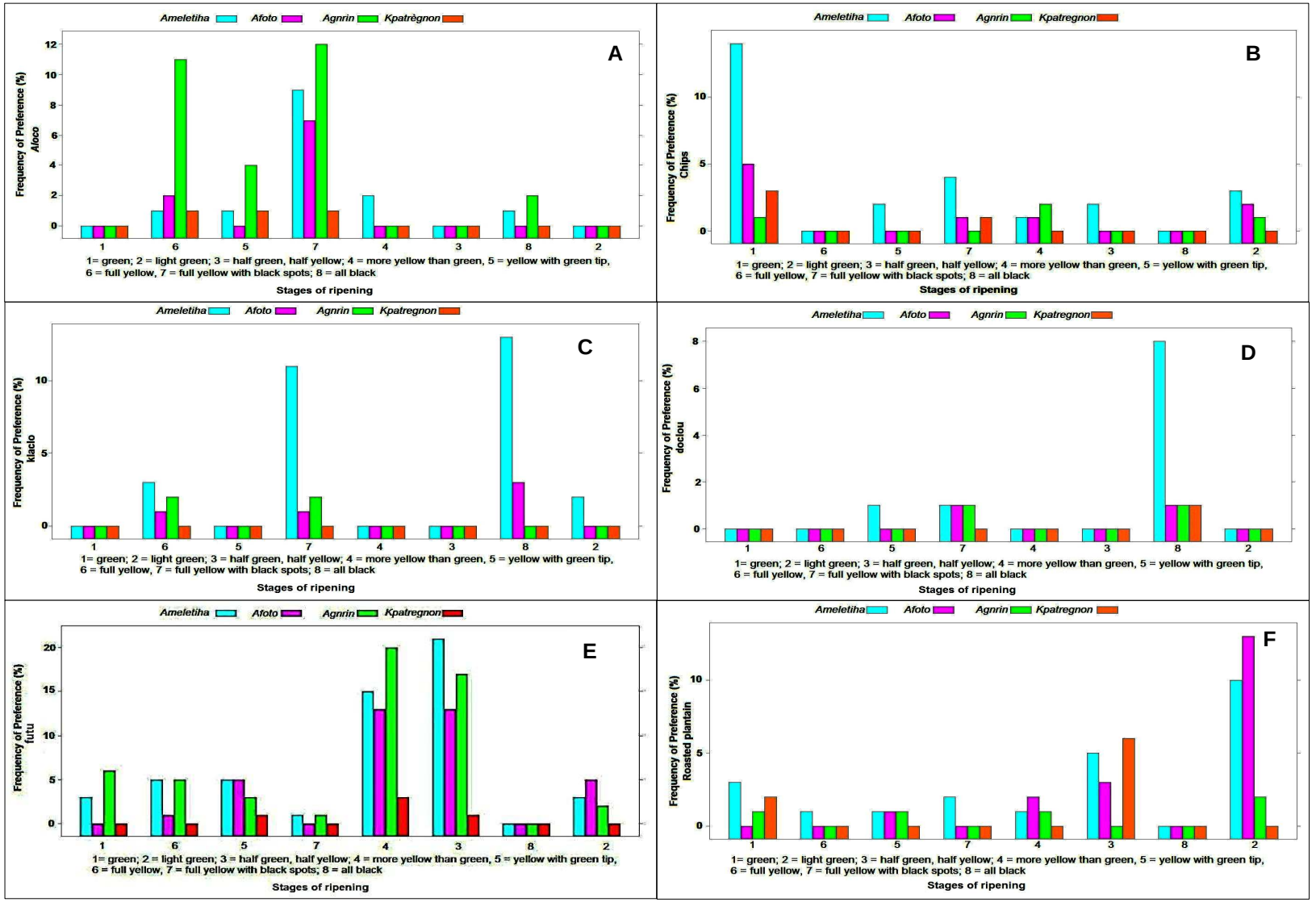

Fig.4 Preference cultivars according to the ripeness stage and the use to make *aloko* (A), *Chips* (B), *klaclo* (C), *doclou* (D) *futu* (E) *and* (F)

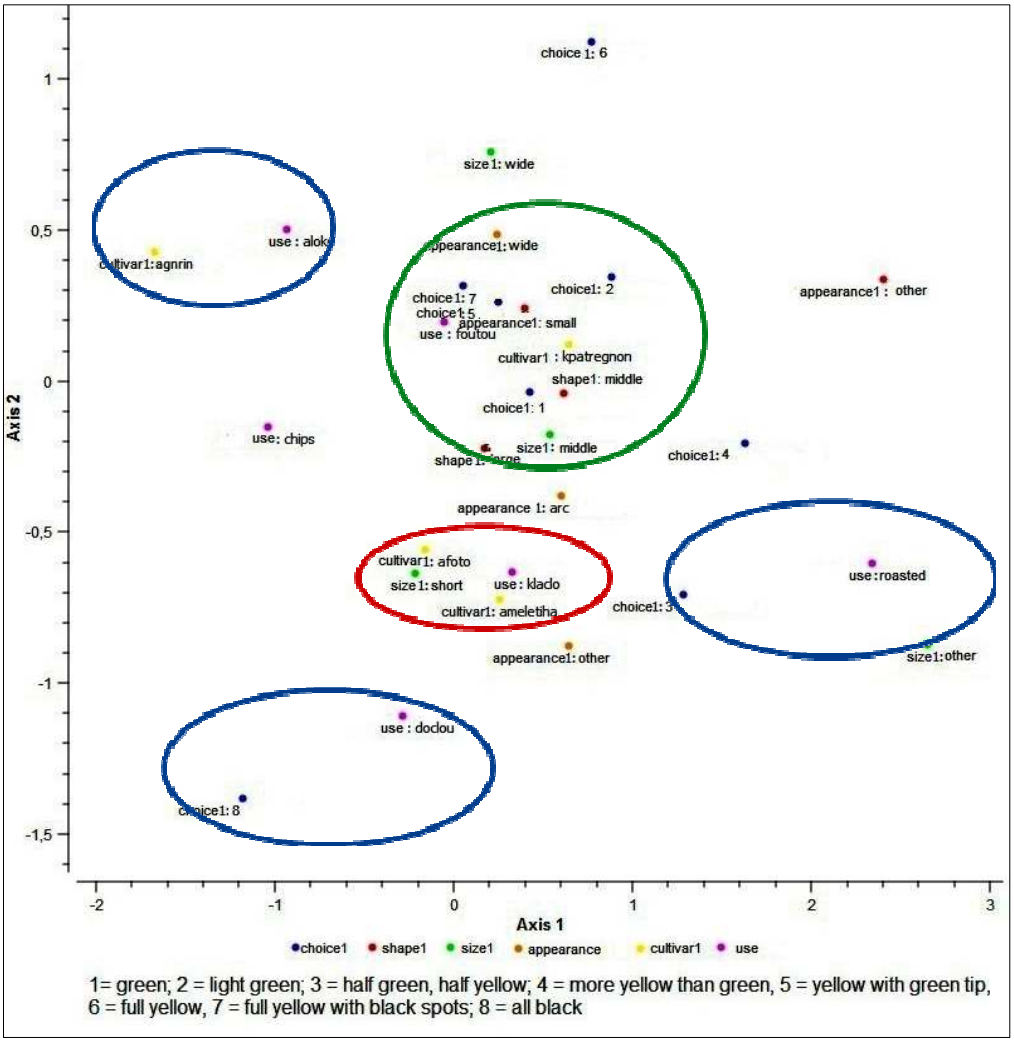

Fig. 5. Interaction between varieties of bananas, ripeness stage, food use and physical characteristics

4. Discussion

4.1. Marketing System In Abidjan Urban Area

Plantain distribution in West Africa is carried out through a variety of interactions between farmers, collectors, wholesalers, and vendors [1]. Indeed, it appears from the Focus Group that the distribution of plantain is from producers (farmers-edge fields sellers) to consumers through mandatory by wholesalers who have exclusive rights to sell plantains on the market. However, consumers can refuel with bananas directly from wholesalers and semi-wholesalers. It is the same for retailers who can also refuel with wholesalers (Figure 1). These results indicated that plantain distribution in Abidjan is simple and organised as reported by Ekow [24], contrary to some countries such as Nigeria and Cameroon. The observed marketing channel and distribution of plantain in our study area is quite similar to plantain value chain in West Africa [25] and do not change from an urban area of the country to another according to N'da et al. [26]. Apart from the fact that in the Ivorian urban context, farmers (producers) cannot sell their products directly to plantain consumers because of the dispersal of the production zones, Daloa, Toumodi, Soubré, Man, Sassandra, etc [11] which are considerably distant

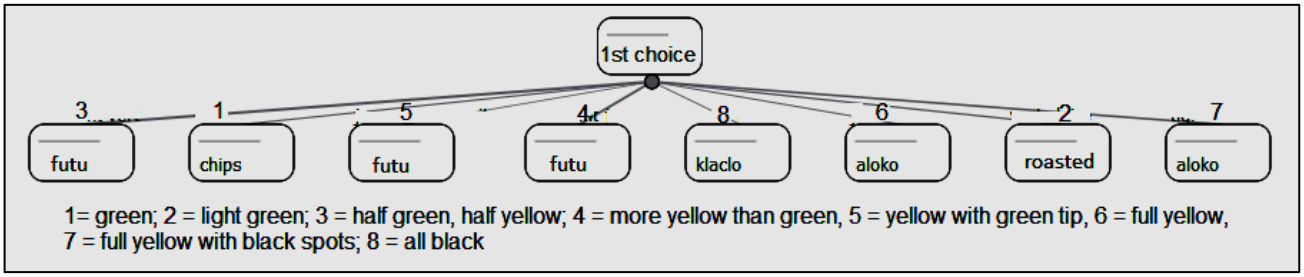

Fig. 6a. Food preference according to the stage of plantain ripeness in the first choice of consumers

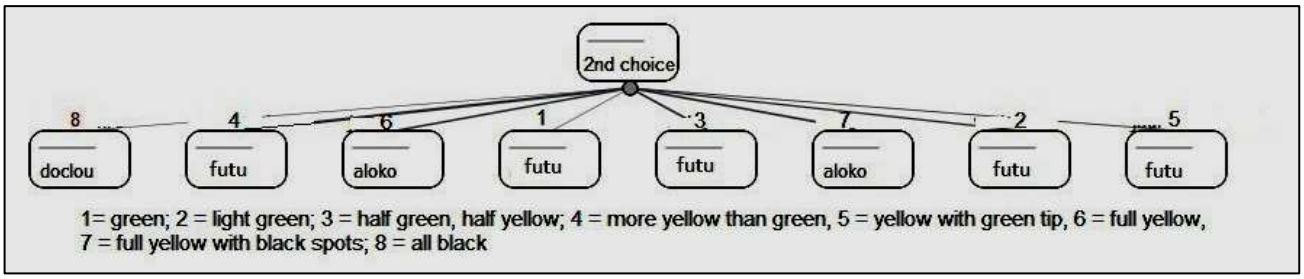

Fig. 6b. Food Preference according to the stage of plantain maturity in the second choice of consumer

Fig. 6. Food Preference according to the maturity of the choices of consumers

from Abidjan. Indeed, the major production areas which supply Abidjan, the main consumption center of the Côte d'Ivoire, are located in the southern half of the country forest and are far from a few hundred kilometers away (300 to 400 km in some cases) [27]. By contrast, banana marketing in places like Cameroon appears more centralized, with wholesalers and large production firms coordinating acquisition of bananas from smallholders, as well the packaging, transportation, and marketing of the produce [28]. Moreover, within the marketing process, transportation is considered one of the most important steps. Fruits are usually transported by trucks. In the Ivorian marketing system, wholesalers who are mostly women, play a significant role in the marketing and sale of plantains [29]. The transportation of bananas is provided by leased trucks. This is explains why, exclusively it was therefore necessary that questions requiring details on household consumption patterns were addressed to women in this study. Osseni et al. [30] confirm that women make a tremendous contribution to food and agricultural production. The research on markets and marketing system of plantain allows a better understanding of the factors affecting demand and supply.

4.2. Most Popular And Preferred Musa Cultivars

In Côte d'Ivoire, the most varieties selected by CNRA (*Centre National de Recherche Agronomique*) for the grown are eight [31]. But our findings indicated that, the most popular cultivars identified included four (4) Musa cultivars merchandized by women plantain trader's on the market Abidjan. There are varieties *Afoto, Agnrin, Ameletiha* and *Kpatregnon* (Table 1). This number was higher relatively than that of a total of three (3) Musa cultivars (*Afoto, Agnrin and Ameletia*) reported in a similar study by Akoa et al. [29] although more urban councils were included in their study as opposed to our study. The higher number of cultivars reported in this study could be due to the survey methodology used, where direct observation (transect walks) was carried out to identify the cultivars. It was established that the findings regarding to the popular cultivars obtained through FGD are *Afoto* variety, followed respectively by *Agnrin*, *Ameletiha* and *Kpatregnon* varieties according to availability in volume of production. However while taking into account the ripening stage, preference of plantains differ from one cultivar to

another (Figure 3). Indeed, during the individual household interviews, respondents showed that *Ameletiha* is most preferred Musa cultivars among the popular plantains followed respectively by *Agnrin, Afoto* and *Kpatregnon* varieties. According to Asseman et al. [32], the first two varieties (plantain "French" kind: *Ameletiha, Agnrin*) have a higher yield and are more available on the markets than *Afoto, Kpatregnon* "Horn" varieties.

4.3. Popular Musa Cooking And Consumer Preference

As indicated earlier, in Côte d'Ivoire, bananas are a major part of the staple diet, particularly among urban populations, complementing other sources of food [10]. Processing methods of plantain vary and lead to different foods [8]. These methods and the cooking of banana fruit in this study range from simple pulp crushing to drying, mixing, boiling and pounding (Table 2). The purpose of processing/cooking is to make the plantain more palatable and digestible. In general, these different cooking methods at several levels of ripeness are justified by the necessity unlike Poyo Banana (Cavendish, AAA) which can be consumed directly as a dessert, or processed into juice, beer and wine [33]. Indeed, technological changes have to change the effects of physical and chemical structures of the final product by promoting the partial enzymatic hydrolysis of starch dispersion [34]. Cooking also increases the digestibility of the starch causing gelatinization, which facilitates enzymatic degradation in the gut [35]. It improves the organoleptic qualities and destroys pathogens [36]. Boiling, roasting or frying of the banana fruit are also common practices in Uganda, Cameroon, Burundi and West Indies [37]. Moreover, it also appears that for most varieties of plantain, interviewees clearly expressed culinary preferences for a particular type of plantain (Figure 4). And for most of these culinary preferences, the choice also depended on one or more stages of fruit maturity (Table 2). These results clearly show that households do not consider the plantain as an undifferentiated whole [38]. They distinguish cooking methods (boiled, roasted or fried), more or less suitable or totally unsuitable for the preparation of each dish. This implies that the cooking would be specific to the desired degree of maturity for each preparation. Similar findings were obtained by Temple et al. [39] who reported that the degree of maturity determines culinary use to be made of plantain. The results of the survey show preference of the people of Abidjan for eleven (11) food preparations containing plantain. Consumer preferences of plantain are shown in Table 2. Of all the staples considered in this study, *Afoto, Agnrin* and *Ameletiha* varieties were the most highly preferred by household for preparations of *futu, aloko, chips, klaklo, doclou* and Roasted plantain (*banane braisée*). Plantains are eaten at all stages of maturity (Figure 3). Thereby, physical post-harvest losses are virtually nil [40]. In Côte d'Ivoire, the predominant mode of consumption of plantain banana is pounded banana or *futu* [8]. This is all true in our study; this dish is the most popular with three varieties of plantain and following five (5) stages of maturity (Table 2). Certainly, because of its disappointment character. Indeed, it would put better in the stomach than rice which is an inconsistent food [39].

Table.2.
Local cooking/processing methods applied to *Musa* cultivars selected

Cultivar local Name (Genomic group)	Ripening stage at use	Traditional culinary preparations	Cooking method	Cooking ingredients	Common accompaniments
Afoto (AAB)	yellow with green tip (stage 5)	*futu*	Boiling	Water, cassava	Various sauces (peanut sauce, palm nut sauce…)
Afoto (AAB)	light green (stage 2)	*futu*	Boiling	Water, cassava	Various sauces (peanut sauce, palm nut sauce…)
Afoto (AAB)	light green (stage 2)	Roasted banana (*Banane braisée*)	Roasting	-	Peanut…
Agnrin (AAB)	more yellow than green (stage 4)	*futu*	Boiling	Water, cassava	Various sauces (peanut sauce, palm nut sauce…)
Agnrin (AAB)	green (stage 1)	*futu*	Boiling	Water, cassava	Various sauces (peanut sauce, palm nut sauce…)
Agnrin (AAB)	full yellow (stage 6)	*aloko*	Deep frying	Salt, Palm oil	Meat, fish, egg, sauce, *attiéké*,
Agnrin (AAB)	full yellow with black spots (stage 7)	*aloko*	Deep frying	Salt, Palm oil	Meat, fish, egg, sauce, *attiéké*,
Ameletiha (AAB)	half green, half yellow (stage 3)	*futu*	Boiling	Water, cassava	Various sauces (peanut sauce, palm nut sauce…)
Ameletiha (AAB)	all black (stage 8)	*klaclo*	Deep frying	Salt, Palm oil	Meat, fish, egg, sauce, *attiéké*,
Ameletiha (AAB)	green (stage 1)	chips	Deep frying	Salt, Palm oil	Directly consumed
Ameletiha (AAB)	all black (stage 8)	*Doclou* or *dockounou*	Boiling	Salt, water	Directly consumed

5. Conclusion

This study allows a better understanding of the factors affecting demand and supply and thus facilitates the prioritization of agricultural research needs. Plantain is a starchy staple in Ivorian diet because of its wide availability on the market and its short-circuit distribution. It helps to design more food available for everyone such as *futu*, cooked on the grill or roasted plantain (*banane braisée*), *chips*, *doclou*, *aloko* and *klaclo*, and regardless of the variety and stage of maturity. *Futu* is the food that is most appreciated with three varieties of plantain and following five stages of maturity.

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