

State Of Knowledge Review On Boiled Plantain

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ABSTRACT

In order to better understand consumers' trait preferences with respect to plantain, a literature review was undertaken to reveal important insights on this topic. Bananas and plantains constitute an important staple food to millions of people in the world. In Cameroon, fruit physicochemical characteristics such as fruit girth, fruit length and peel thickness are important criteria for householders in the choice of plantain cultivars for specific uses. This is backed up by the fact that some households assumed that plantain fruits with high peel thickness are easier to peel. Other parameters such as pulp to peel ratio, pulp firmness, total soluble solids, pH, total titratable acidity and dry matter content which are evaluated during ripening are also of great importance. Using various sources of energy (firewood, gas or kerosene cooker), unripe and ripe plantain pulps are sometimes cooked with salt and specific average quantity of water within a well-defined time. The boiling time been dependent on the ripening stage of the pulp, its grade and the plantain cultivar. The steps involved in plantain pulps preparation are: (i) fruit peeling and scrapping off the tiny membrane covering the pulps; (ii) pulp washing and cutting into pieces if they are large enough; and (iii) pulp cooking with a sufficient quantity of water within a precise cooking time. Apart from the consumers' physical traits preferences in Cameroon, few or no information is given regarding the organoleptic characteristics and the quality of boiled plantain at each steps of processing. The supply system of plantain include producers, wholesalers, collectors, loaders and transporters. Plantains are an important source of income for smallholder farmers and sellers in west and central Africa.

RESUME

Dans l'optique de mieux comprendre les préférences des consommateurs des pulpes bouillies de plantain, une revue de la littérature a été réalisée. Les bananes et plantains constituent l'alimentation de base des millions de personnes dans le monde. Au Cameroun, les caractéristiques physicochimiques telles que le grade du fruit, la longueur du fruit et l'épaisseur de la peau sont des critères importants qui guident le choix des cultivars de plantain pour des utilisations spécifiques dans les ménages. Ceci est d'autant plus vrai que certains ménages confirment préférer les plantains dont l'épaisseur de la peau est élevée car ceux-ci sont faciles à éplucher. Certains paramètres tels que le rapport pulpe peau, la fermeté de la pulpe, le taux d'extrait sec soluble, le pH, l'acidité totale titrable et le taux de matière sèche qui sont évalués au cours du murissement sont aussi d'une grande importance. En utilisant diverses sources de chaleur (feu de bois, gaz ou réchaud à pétrole), les pulpes mûres ou non de plantain sont souvent cuites avec du sel et des quantités moyennes d'eau spécifiques pendant des durées bien définies. Ces temps de cuisson dépendent essentiellement du stade de murissement de la pulpe, de son grade et du cultivar de plantain. La préparation des pulpes de plantain se fait selon les étapes ordinaires suivantes : (i) épluchage du plantain et raclage de la fine couche qui recouvre la pulpe ; (ii) lavage des pulpes et découpage en morceaux si les pulpes sont longues et larges ; (iii) préparation de la pulpe avec assez d'eau pendant une durée précise. En dehors des préférences physiques des consommateurs au Cameroun, très peu ou aucune information existe en ce qui concerne les caractéristiques organoleptiques et la qualité de la pulpe bouillie de plantain à chaque étape de transformation. La chaîne de valeur du plantain comprend les producteurs, les collecteurs, les chargeurs, les transporteurs, les grossistes et les détaillants. Le plantain constitue une source importante de revenus pour les intervenants dans la filière (paysans, commerçants, transformateurs, etc.).

LITERATURE REVIEW ON BOILED PLANTAIN

1. FOOD SCIENCE CONTEXT

1.1. Plantain cultivars mostly consumed in Cameroon

Bananas and plantains are members of the *Musaceae* family and provide a dessert fruit (banana) or a starch staple food (plantain) to millions of people in the world. In Cameroon, a large number of plantain varieties is grown by farmers. Honfo *et al.*^[1] reported in 2011 that the most consumed plantain cultivars in Cameroon were “*Ebang*” and “*Essong*”, following a survey carried out on 240 households in four towns namely Bafia, Bamenda, Bertoua and Ebolowa.

A similar survey previously done in 2005 by Ngoh Newilah *et al.*^[2] in Bafoussam and Yaoundé including 128 respondents revealed that in addition to “*Ebang*” and “*Essong*” other plantain cultivars such as “*Elat*”, “*French clair*”, “*Big ebanga*”, “*Kelong mekintu*” and “*One hand planty*” were mostly consumed by Cameroonians as well. According to Ngoh Newilah *et al.*^[2], the local names of these cultivars differ from one family to another even in the same ethnic group. Besides being numerous, their mode of consumption, though being boiled, varies according to consumer’s preferences as they could be consumed green, half-ripe, ripe or over-ripe.^{[1] [2]}

In Cameroon, housewives were able to name promptly and describe precisely at least one type of plantain. Signs of recognition are complex and different from one person to another. The housewives describe different cultivars using the size of the bunch (weight or length), the number of hands per bunch, the size of the fingers in diameter and/or length, the number and appearance of fingers (hold-tight or not), the skin colour (red, light green, dark green, black, black and white, grey, etc.), the presence of stripes on the skin, and the pulp colour (pink, white or red) or appearance (light). Under the survey conditions (only a small number of people interviewed, and no external control), it was difficult to know if the same name given by two different people corresponded to the same cultivar, and conversely if two different names corresponded to two different cultivars^[12].

Concerning favourite cultivar, 1/2 to 2/3 of housewives had a preference for specific cultivars dedicated to defined preparations. For each culinary preparation they describe an unsuitable plantain. Plantain is usually preferred at its green stage for almost every type of preparation except for frying and roasting. Even for these types of cooking, many differences in taste preferences appeared. Children, some women and most Europeans prefer fried plantain from ripe fruits whereas most Cameroonians prefer fried or roasted plantain from unripe fruits^[12].

1.2. Physicochemical characteristics of plantain fruits

In Cameroon, fruit physicochemical characteristics such as fruit girth, fruit length and peel thickness, which are measured only at harvest, are important criteria for householders in the selection of plantain cultivars for specific uses^[3]. For example, households assumed that plantain fruits with high peel thickness are easier to peel. In a study on the effect of ripening on some physicochemical composition of 11 plantain cultivars and 4 *Musa* hybrids grown in Cameroon, the fruit girth ranged from 3.64 to 5.93 cm, while the fruit length varied between 22.10 to 43.60 cm and the peel thickness from 3.03 to 4.20 mm^[3]. Also, a study carried out by Andre *et al.*^[4] on a collection of 35 *Musa* sp. cultivars, indicated a closely similar trend regarding peel thickness (2.6 to 3.6 mm). In addition, the same investigation showed data on fruit mass (136.8 to 221.9 g), percentage of edible fraction (61.7 to 64.8 %), the pulp and peel water content respectively (60.8 to 61.4 % fresh weight and 86.6 to 87.4 % fresh weight).^[4]

At harvest, plantain peel colours were dark green, green, green with black spots, green with chestnut pigments, green yellowish, chimeric green white according to the cultivars of plantains and may be the production locality^{[4] [5]}. The colour of the pulp was orange for the only plantain cultivar evaluated at that time (French Sombre)^[5]. Moreover, in 2008, Ngoh Newilah *et al.*^[6] evaluated bananas and plantains grown in Cameroon as a potential source of carotenoids. Of the 104 cultivars evaluated in this study, 16 were cooking bananas, 21 were dessert bananas, 47 were plantains, 5 were plantain hybrids and

15 were Papua New Guinea (PNG) cultivars. They were all analysed for their flesh coloration. Among these *Musa* types investigated using two colour fans (one based on the flesh colour variation in potato developed on the initiative of the CGIAR HarvestPlus Challenge Programme and the other based on egg yolk colour variation developed by DSM)^[6], PNG cultivars namely “*Hung tu*” (AA) and “*Manameg red*” (AAA) pulps scored highest orange colour compared to plantains, dessert bananas, plantain-like hybrids and cooking bananas. The 14 elite plantain cultivars evaluated in Nigeria by Ubi *et al.*^[7] presented brown, milky white, creamy or whitish pulp colours.

Other parameters such as pulp to peel ratio, pulp firmness, total soluble solids, pH, total titratable acidity and dry matter content were evaluated during ripening. Pulp firmness is a maturity index and is important in the evaluation of fruit susceptibility to physical or mechanical damage. At harvest, the pulp firmness varied from 2.54 to 3.48 kg/m², at stage 3 (half-ripe) it varied from 1.80 to 2.54 kg/m², at stage 5 (ripe) it ranged between 1.23 to 1.48 kg/m² ^[3].

The assessment of pH and titratable acidity of *Musa* cultivars is primarily used to estimate consumption qualities and hidden attributes. At harvest, the pH of *Musa* peels ranged from 5.36 to 5.86 respectively for “*FHIA21*” and “*CRBP755*”^[3]. During plantain pulp ripening, these values rarely change significantly. Likewise, Andre *et al.*^[4] have peel pH ranging from 5.1 to 6.4 for “*Mujuba*” and “*Figue Rose*” respectively. Unlike the peels at harvest, *Musa* pulps showed high pH values closer to 6 with “*Mbouroukou*” having the highest value (6.19) and “*Red Yade*” the lowest (5.83)^[3]. Similarly, Andre *et al.* had pulp pH values ranging between 5.1 to 6.7 respectively for “*Mujuba*” and “*Tomolo*”. These values decreased significantly during post-harvest maturation [4.83 to 5.01 at stage 3 (half ripe) and 4.54 to 4.65 at stage 5 (ripe)]^[3]. On the other hand, total titratable acidity (TTA) levels at harvest ranged from 300 to 500 mEq/100g with a plantain-like hybrid “*FHIA 21*” having an exceptional value of 509 mEq/100g. These values increased significantly from unripe to ripe stage.^[3] TTA could be considered as a good indicator of fruit ripeness. Acids make an important contribution to the post-harvest quality of the fruit, as taste is mainly a balance between the sugar and acid contents^[3].

The total soluble solid (TSS) content of a fruit is a useful index of maturation since its value increases during ripening, as it is based on soluble compounds such as sugars, acids, vitamin C, amino acids and some pectins. Ngoh Newilah *et al.* (2011) had values ranging from 1 to 2g/l, with “*FHIA21*” and “*Elat*” showing highest values 2.8 and 2.03 g/l respectively.^[3] These values increase significantly during ripening with increasing factors ranging from 5 to 11 and from 6 to 13 for unripe to ripe stage and for unripe to fully ripe stage respectively.^[3] At all ripening stages, most plantain cultivars showed higher TSS levels compared to hybrids. On the other hand, results obtained by Andre *et al.* (2014) showed highest values, as the soluble solid contents at harvest ranged from 2.9g/l to 4.8 g/l respectively for “*Figue pomme Ekona*” and “*Iho-U-Maohi*”^[4]. These results confirm the subjectivity related to the determination of maturation stage through visual observation.

Pulp to peel ratio (pu/pe) is an important post-harvest quality index in the evaluation of the cooking quality of matured green plantain as consumers often prefer thicker and bigger pulps (pu/pe>1). Ngoh *et al.* (2009) in their study on the physicochemical changes during ripening of bananas grown in Cameroon revealed that the pu/pe ratio of the 9 *Musa* cultivars analysed, was greater than 1 at harvest, although “*Popoulou*” exhibited a value of 3.43. This ratio increased significantly from 1 to at least 2.5 at fully ripe stage, “*Pisang mas*” and “*Popoulou*” pulps weighing about 8 times more than their peels^[8].

Pulp and peel dry matter content provide plant breeders with information in determining whether increased yield is due to high water content or due to genuine increase in harvested weight. Ngoh Newilah *et al.* (2011) revealed that the dry matter contents of the plantain pulps were significantly higher ($p<0.05$) than those of the hybrids, they ranged respectively from 34-39 g/100g fresh weight and from 31-34 g/100g fresh weight.^[3] Similar results were obtained by Andre *et al.* (2014) and Ngoh Newilah *et al.* (2009)^[4] ^[8]. During maturation, there is a considerable decrease from 2 to 4 units of the pulp dry matter content. However, the peel dry matter content at harvest which ranged from 7 to 13g/100g fresh weight for “*Batard*”, “*Big Ebanga*” and “*Biya2*” had a reverse trend with respect to the pulp dry matter content as its values increased during ripening to 19-20 g/100g fresh weight (“*A11*”)^[3].

1.3. Nutritional qualities of plantain fruits

The peel and the pulp of plantain cultivars had variable amounts of micronutrients. High amounts of potassium were found on the peel (> 5000 mg/kg dry weight) and in the pulp (> 1000 mg/kg dry weight), making this element the most abundant in plantain cultivars analysed, namely “*Batard*” “*Mbouroukou n°3*” and “*Mbouroukou n°1*”. Magnesium, Calcium, Phosphorus and Sulphur were also present in ranges of 5.3-113 mg/kg dry weight at the level of the pulps and 51.6-309.2 mg/kg dry weight at the level of the peels of the above mentioned plantain cultivars. Minerals such as Iron, Copper, Manganese, Zinc and Boron appeared in traces at the level of their pulps (<1.5 mg/kg dry weight)^[9].

The nutritional characteristics of boiled plantain have been evaluated by Ngoh Newilah *et al.*^[7] showed that it contains carbohydrates (77.68 g/100g dry weight), lipids (13.00 g/100g dry weight) and proteins (3.55 g/100g dry weight), with an energy value of 441.86 kcal/100 g dry weight. Besides, it is rich in Potassium and Phosphorus (>100 mg/100 g dry weight), less rich in Calcium and Magnesium (<11 mg/100 g dry weight) and contains about 2.43 mg/100g dry weight of Sodium. Manganese, Copper and Iodine appeared in traces (<1 mg/100g dry weight). Moreover, the physicochemical attributes of boiled plantain in this study revealed that the pH is 4.99, the total soluble solids is 32.2 g/l, the TTA is 4125mEq/100g fresh weight, the water content is 64.63 g/100g fresh weight, the dry matter content is 35.37 g/100g fresh weight and the ash content 5.78 g/100g dry weight^[10]. In Nigeria, some organoleptic characteristics of plantain cultivars were evaluated in general and particularly the taste of the pulp that was either salty, sweet, very sweet or sour^[7].

1.4. Preparation and processing steps

Concerning the quality of boiled plantain at each steps of processing, few information are available. In 2005, following a survey in two Cameroonian towns (Bafoussam and Yaoundé), Ngoh Newilah *et al.* indicated that plantain pulps are sometimes cooked with salt, using various sources of energy (firewood, gas or kerosene cooker) for about 63 min with approximately 2031 mL of water for 2396 g of unripe pulps or 36 min with about one litre of water for 2486 g of ripe pulps^[2]. They also stated that boiling time depends on the ripening stage of the pulp, its grade and the plantain cultivar.

In addition to boiled plantain, Ngoh Newilah *et al.* found 11 additional plantain-derived dishes consumed in these towns namely: plantain paste lined with bean or vegetable, *Kondre* of plantain, fried plantain and plantain chips, *Bouillon* of plantain or *Douala-midi*, plantain lined with green leafy vegetables, roasted plantain, *Malaxé* of plantain, plantain mixed with *Egussi* paste, *Ntuba* or pounded plantain, *Mielemassesse* or *sauté* of plantain and traditional *purée* of plantain^[2]. The main characteristic of these dishes is that the plantain pulp is boiled. Furthermore, the influence of two boiling times on total carotenoid content of a plantain cultivar (*Batard*) was studied in 2008 by Ngoh Newilah *et al.* The culinary preparations included boiling the entire fruit (unpeeled) and boiling the pulp alone (peeled fruit). Compared to unprocessed pulps, the cooked pulps presented significantly low total carotenoid levels.^[6] In 2018, three main steps was described in order to obtain boiled plantain, namely: (i) fruit peeling and scrapping off the tiny membrane covering the pulps; (ii) pulp washing and cutting into pieces if they are large enough; and (iii) pulp cooking with a sufficient quantity of water within a specific cooking time based on the fruit's grade and the ripening stage (water can first be boiled for rapid water diffusion before introduction of the pulps)^[10].

In Eastern Democratic Republic of Congo, plantain cultivars are mostly utilized between stages 1 and 3 of ripening. The fruits are generally peeled and boiled with salt. Sometimes, the pulps can be cooked with processed palm oil. Some cultivars were boiled without salt because of their natural sweetness.^[11] In Nigeria, the fingers of ripe or unripe plantain are peeled and cooked in boiling water or vapour for 20 to 50 minutes depending on the cultivar and ripening stage of the fruit.^[7] Irrespective of the country, these boiled pulps are eaten either alone or with sauces (tomato or groundnut), fried vegetables, fried kidney beans, *koki*, roasted fish and meat (pork, beef, chicken).^{[2] [10] [11]}

2. GENDER CONTEXT

According to Egwu Bime *et al.*^[13], the most active population in plantain production and commercialization activities was within age range of 35 to 45 years. The number of years of experience in plantain cultivation and commercialization ranged from 1 to 50 years. 57.3% of men against 48.48% of women had been cultivating and commercializing plantains between 1 to 10 years while 1.3% of men as against 3.0% of women had been cultivating and selling plantains for 41 to 50 years and the majority of respondents had a farm size of 7 hectares where they produce plantains in association with other crops. Also, 29.1% of proceeds from the farms belong to men alone in the study area while 24.1% belong to women while 45.4% of the proceeds belong to both men and women jointly. Even though 45.4% of these proceeds are jointly owned, this money cannot be spent by the women without the consent of the men. Also, results shows that, only 1.3% of men cultivate plantains for household consumption mainly while no woman does that. This is in contradiction Temple *et al.*, (2006) who stated that almost 40% of the total production is for home consumption. 36% of men against 28.8% of women cultivate plantains for commercial purposes mainly. 62.7% of men against 71.2% of women cultivate plantains for both household consumption and for commercial reasons^[13].

3. DEMAND AND MARKET CONTEXT

3.1. Demand

Plantain quality characteristics differ with personal preference, age, sex and sociocultural origin. The most important criteria for buyers is the maturity of the fruit defined by two elements, the level of filling of fingers and the pulp colour, although buyers rarely break the fingers to see the pulp colour when they buy the plantain in the market. Also, traders also look for a fresh and bright appearance of the bunch that reflect good transportation conditions^[12]. The bunch which has reached maturity and ready for harvest presents certain external characteristics such as: - 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)^[14].

3.2. Market

3.2.1. Actors

The different types of actors identified and involved in the supply system of plantain in Cameroon are: producers, wholesalers, collectors, loaders and transporters^[17]. Plantain can be grown all year round, but yields vary with rainfall and agronomic practices, which affects planting and harvest schedules. This results in a seasonal supply that causes price fluctuations. This instability constitutes a major disadvantage for producers in the context of climate change. Furthermore, there are three major periods for the availability of plantain in markets of big Cameroon cities: the first from January to April, is a period of abundance. Indeed, this period of the year corresponds to the dry season which runs from November to March. Between June and September is a period of real shortage. This can be justified by the rainy season which is experiencing its highest rainfall between July and August. The other months (April-May and October-December) can be termed buffer or intermediate months between scarcity and abundance^[17].

3.2.2. Transportation

In the traditional channel, the plantain is generally transported in bunches 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 bunches to be carried, the distance to run and local removing methods^[14]:

- Carried by people (1 to 3 bunches);
- Trolley pushed or pulled by people (15 to 25 bunches);
- Bicycle or motorcycle (1 to 7 bunches);

- On the roof of travellers' transport van (50 to 60 bunches);
- Truck (400 to 700 bunches);
- By railway (more than a thousand bunches).

3.2.3. Marketability

The most expensive plantains do not necessarily have the longest or biggest bunches: 76% of the most expensive plantain types had small or average bunches. The cheapest are often long or are average in size. Thus the main criteria for consumers is the finger size, while traders like size of the bunch. Preparation cost is considered expensive for four out of nine types of preparation: fried, chips, stuffed and malaxé. The less expensive preparations are roasting, boiling, soup and sauté. Difference due to the cost of oil that doubles the price of the meal, as 1litre of oil (palm oil, crude or refined paid between 600 and 1200fcfa) is used for the preparation of one 1000fcfa heap (*this was in 2002, these prices have surely change by now*).

3.2.4. Income generation

Plantains are an important source of income for smallholder farmers in west and central Africa, partly because of their low labor requirements for production compared to crops like cassava, rice, maize, and yams^[15 & 16]. In addition to the income opportunities for farmers, processed plantains provide employment for women. In Cameroon, roadside women sell fried plantain dish, plantain chips, roasted plantain and other snacks^[2].

4. CONCLUSION

In the midst of these data, plantain characteristics at harvest are cultivar-dependent and householders choose their cultivar depending mostly on the pulp colour, the fruit grade or the intended use of the latter. Boiled plantain is consumed either from unripe, half-ripe, ripe or over-ripe plantain, and is a rich source of Potassium and Phosphorus. The cooking method depends on the ripening stage and the grade of the fruit. The supply system of plantain in Cameroon include producers, wholesalers, collectors, loaders and transporters. Plantains are an important source of income for smallholder farmers and sellers in west and central Africa. However, little information is known on the quality characteristics at each processing steps and the quality characteristics of the final product (including some nutritional facts and sensory characteristics) in Cameroon.

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