Research Article

Received: 26 December 2022 Revised: 3 October 2023 Accepted article published: 1 November 2023 Published online in Wiley Online Library:

(wileyonlinelibrary.com) DOI 10.1002/jsfa.13090

User preferences and consumer acceptability of boiled plantain in rural and urban localities in Cameroon

Gérard Ngoh Newilah,[a,b*] Cédric Kendine Vepowo,[b,c] Raymonde Nya Nzimi,[a] Cédric Kuate Kengne,[a] Annie Takam Ngouno,[a] Claudin Karim Nana,[a] Vivien Meli Meli,[a] Inocent Gouado,[c] Dominique Dufour[d] and Didier Mbeguie-A-Mbeguie[d,e]

Abstract

BACKGROUND: An understanding of the preferences of different stakeholders in the plantain value chain in rural and urban segments in Cameroon is important for the selection and adoption of new plantain cultivars. Boiled plantain is one of the most commonly consumed food products from this crop in Cameroon. Gendered food mapping and consumer testing with two plantain landraces (*Batard* and *Big Ebanga*) and a plantain-like hybrid (*CARBAP K74*) was carried out in rural and urban areas in the West and Littoral regions of Cameroon.

RESULTS: Plantain users in these two regions were categorized into producers, traders, processors, and consumers. Preferences indicated that raw plantain should bear long and large fruits, with heavy bunches, and an orange pulp color, whereas boiled plantain should present with a yellow color and a soft and mealy pulp, with a good plantain aroma. *Batard* and *Big Ebanga* were liked moderately by consumers, whereas *CARBAP K74* was liked slightly. *CARBAP K74* was on par with *Batard* and *Big Ebanga* for some attributes, except for color and sweetness.

CONCLUSION: More emphasis should be given to attributes such as color, firmness, and taste for the development of new plantain clones to be adopted by end users consuming boiled green plantain.

Keywords: stakeholders; selection criteria; plantain value-chain; efficient breeding

INTRODUCTION

Plantain (*Musa* spp.) is a perennial crop cultivated in many tropical and subtropical countries and it is regarded as an important source of starch for millions of people in West and Central Africa.[1,2] The importance of plantain is underpinned by its value for food security and job creation.[3] In 2020, the production of plantains and cooking bananas was estimated at 32 420 031 MT in sub-Saharan Africa, with Cameroon producing about 4 523 625 MT.[4] Plantains are usually prepared in different forms – for example, boiled, roasted, fried, pounded, as porridge, and as flour, depending on the ripening stage.[5-7] In Cameroon, the most commonly preferred dish is boiled plantain prepared using ripe plantain with a peel more yellow than green.[8]

To meet the ever increasing demand for plantain, several research centers, including the Centre de Coopération Internationale en Recherche Agronomique pour le Développement (CIRAD) in the French West Indies, the International Institute of Tropical Agriculture (IITA) in Nigeria, Empresa Brasileira de Pesquisa Agropecuária (EMBRAPA) in Brazil, the Fundación Hondureña de Investigación Agrícola (FHIA) in Honduras, and the Centre Africain de Recherches sur Bananiers et plantains (CARBAP) in Cameroon, have embarked on plantain varietal improvement. The increased pressures of pests and diseases on plantains and bananas have

* *Correspondence to: Ngoh Newilah G, University of Dschang, PO Box: 96 University of Dschang, Cameroon. E-mail: gbngoh@gmail.com*

a *University of Dschang, Dschang, Cameroon*

b *Centre Africain de Recherches sur Bananiers et Plantains (CARBAP), Douala, Cameroon*

c *University of Douala, Douala, Cameroon*

d *Centre de Coopération Internationale en Recherche Agronomique pour le Développement (CIRAD), UMR Qualisud, Montpellier, France*

e *Laboratoire de biochimie alimentaire et des produits tropicaux, UFR Sciences et Technologies des Aliments (UFR STA), Université Nangui Abrogoua, Abidjan, Ivory Coast*

motivated the development of varieties that are pest and disease tolerant. Despite their good agronomic characteristics (high yield and tolerance to biotic stresses), adoption rates have been limited.[9,10] This is largely due to the lack of attention given by banana-breeding programs to end users' demands for quality traits, which has resulted in a reluctance to adopt the new varieties.[11]

Plantain production, like the production of other bananas, is still dominated by farmer-preferred local varieties (landraces) mainly because of their consumer-preferred attributes.[12,13] Recent studies by Ngoh Newilah *et al*. highlighted quality characteristics for poor and good plantains in rural areas.[14] These characteristics could be different or similar in urban areas, hence the necessity for further research.

Consumer testing could also help to improve the boiled plantain quality profile by supplying breeders with additional information regarding selection criteria. Consumer tests are useful tools for product development, screening of products, and confirming that they meet the targeted acceptance levels.[15] Such studies must consider factors like appearance, fragrance, texture, and taste, among others, as they frequently have an impact on consumer preference for a certain crop variety.[16,17] A recent study revealed that, in Cameroon, taste was the most important factor affecting choices in consuming fresh plantains and their products.[8] Sanya *et al*. highlighted that better consumption attributes such as taste, texture, and color could increase the likelihood of adopting improved banana hybrids by farmers in Uganda.[18] With these results, it is obvious that sensory evaluation studies of consumer preference are important for demand-driven breeding techniques but they are still difficult to conduct with low-income consumers in Africa.[19] This study therefore aimed to evaluate the factors that guide the choices of the end users (producers, traders, processors, and consumers) of the plantain value chain as well as the consumer acceptability for boiled plantain in rural and urban areas in Cameroon.

MATERIALS AND METHODS

Study area

This study had two phases. The first phase consisted of gendered food mapping. It focused mainly on quality characteristics of raw and boiled plantains. It was carried out in eight neighborhoods in urban areas from January 23 to January 28, 2020, in Douala, Littoral region, and from February 13 to February18, 2020, in Bafoussam, West region. It followed a methodology developed by Forsythe *et al*.[20] The second phase, concerning consumer testing, was carried out in the West and Littoral regions of Cameroon during from November 9 to November 18, 2020, using the protocols reported by Fliedel *et al*.[21] The various study sites are highlighted in Fig. 1.

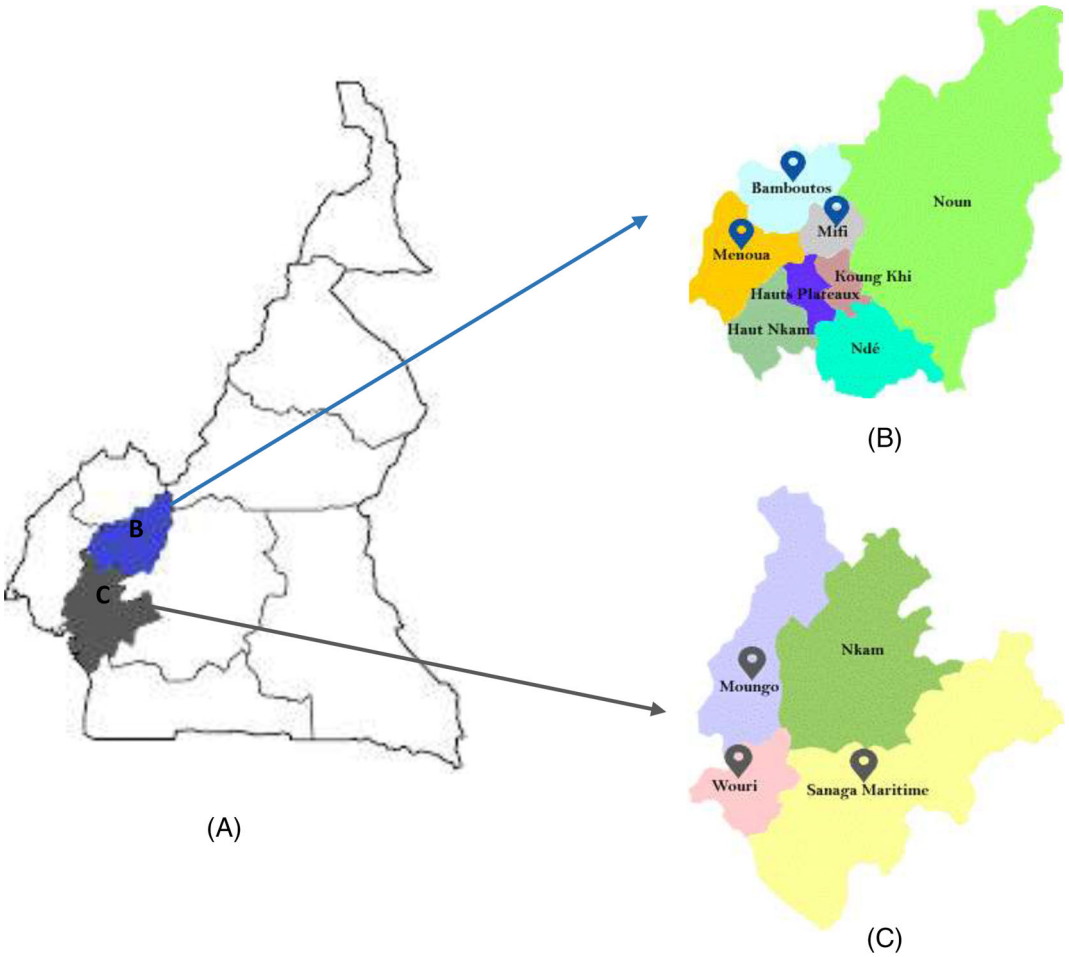

Figure 1. Research sites. (A) An overview of Cameroon with the West and Littoral regions highlighted. (B) An overview of the West region with the Mifi, Menoua, and Bamboutos divisions located. (C) An overview of the Littoral region with the Moungo, Wouri, and Sanaga-Maritime divisions located.

Journal of The Science of Food and Agriculture published by John Wiley & Sons Ltd on behalf of Society of Chemical Industry.

Plant material

Two plantain landraces (*Batard* and *Big Ebanga*) and one plantain-like hybrid (*CARBAP K74*) were used for this activity (Fig. 2). These varieties were grown at CARBAP's experimental plot in Njombe (4° 34′ 50″ N, 9° 39′ 53″ E, ≃ 74 m above sea level), using a spacing of 3 m × 2 m under rain-fed conditions. Bunches were harvested at their optimal physiological maturity, characterized by the appearance of a turning finger (a 'start ripe finger') on the first or second hand.

Gendered food mapping at urban level

The survey was carried out in eight neighborhoods: four in Douala (Boko – Village quarter; Deïdo – Grand Moulin quarter; Bonabéri – Sodiko quarter, and Cité des Palmiers) and four in Bafoussam (Nylon, Djeleng, Ngouache II, and Kouogouo) using the multidisciplinary methodology described by Forsythe *et al.*[20] Participants were plantain farmers, processors, and consumers of boiled plantain, who were selected randomly from the different localities. In total, 16 focus-group discussions (FGD) (eight male and eight female groups, each with at least 10 persons), 32 market interviews (MIs), 16 restaurant interviews (RIs), and 80 individual interviews (IIs) were held. The purpose was to identify quality characteristics of raw and boiled plantain along the food chain by different stakeholders.

Preparation of boiled plantain samples

Plantain fruits were detached from the bunch, washed, and peeled. The resulting pulps were scraped and soaked in water to prevent oxidative browning; meanwhile, pots containing approximately two liters of water were brought to a boil. Pulps of each variety were then introduced into their corresponding pots immediately when water started boiling. While the plantain pulps were boiling, additional hot water was added to the pots (after 30 min) to ensure complete immersion of the pulps. After 60 min, when cooking was complete, boiled pulps were drained, placed in small rectangular containers, and stored in a thermos flask containing hot water (temperature ≥ 95 °C) to retain a temperature between 55 °C and 60 °C before sensory evaluation.

Sample presentation

Boiled plantain samples (three in total) were served in transparent cylindrical boxes with subjects handling samples with stainless-steel forks. The boxes, identified with a three-digit code, containing a slice of about 1–2 cm thick boiled plantain sample, were presented in a random order. Mineral water was provided to consumers to cleanse their palates between samples.

Consumer testing

Passers by of both genders in each locality were invited to participate in the tests. Before tasting, consumers were questioned about their consumption habits regarding boiled plantain, and only adults (above 18 years) who regularly consume boiled plantains were invited to participate in the tests after signing a consent form. A total of 300 consumers were randomly interviewed in both regions. In addition to the rural localities (villages) previously surveyed,[14] small towns and big cities in each region were also surveyed. The localities surveyed per region, alongside the number of participants were:

- Littoral region ($n = 150$): Douala ($n = 60$); Pouma ($n = 30$); Njombe ($n = 15$), Kombe ($n = 15$), Song-mayo ($n = 15$), Sokelle ($n = 15$).
- West region ($n = 150$): Bafoussam ($n = 60$); Dschang ($n = 30$); Bafounda ($n = 15$), Bamendjing ($n = 15$), Balessing ($n = 15$), Penka-michel ($n = 15$).

A method including a hedonic test, a just-about-right (JAR) test, and a check-all-that-apply (CATA) test was used.[21] Consumers were asked individually to look, touch, smell, and taste each of the three boiled plantain samples, one after the other, in a random order, and score the overall liking using a 9-point hedonic scale (from 1. 'Dislike extremely' to 9. 'Like extremely'). Consumers were also asked to assess how they perceive the intensity of the four characteristics previously identified as important in both rural and urban settings[14] using the 3-point 'Just About Right' (JAR) scale (1 = 'Too low, too weak, not enough', 2 = 'Just about right' and 3 = 'Too high, too strong, too much') for each of the three boiled plantain samples.

JAR attributes were:

- Color: too clear; JAR; too dark.
- Texture in the mouth: not firm enough; JAR; too firm.
- Humidity: too wet; JAR; too dry.
- Sweet taste: not sweet; JAR; too sweet

Photo 1. A bunch of *Batard*

Photo 2. A bunch of *CARBAP K74* hybrid

Photo 3. A bunch of *Big ebanga*

Figure 2. Bunches of the plantain varieties used for consumer testing.

Journal of The Science of Food and Agriculture published by John Wiley & Sons Ltd on behalf of Society of Chemical Industry.

Table 1. Socio demographic characteristics of survey participants

Focus groups discussions

(Number of participants = 167: 83 men; 84 women); age (mean ± SD): 34.3 ± 12.1 years

Ethnicities	Bafoussam (%)	Douala (%)	Profession	Bafoussam (%)	Douala (%)
Bamileke	70.77	17.69	Artisan	11.98	8.38
Banso	0.00	1.54	Civil servant	4.19	6.59
Bassa	0.00	3.85	Driver	1.80	0.60
Bayangi	0.00	0.77	Jobless	9.58	8.38
Beti	0.00	0.77	Retired	0.00	0.60
Eton	0.00	0.77	Student	22.16	13.77
Ibo	0.00	2.31	Trader	5.39	6.59
Mbam	0.00	0.77			
Yabassi	0.00	0.77			

Individual (producers + consumers) interviews

(Number of participants = 80: 39: men; 41 women); age (mean ± SD): 40.4 ± 13.4 years

Ethnicities	Bafoussam (%)	Douala (%)	Profession	Bafoussam (%)	Douala (%)	Marital status	Bafoussam (%)	Douala (%)
Bafut	0.00	1.25	Artisan	16.25	13.75	Divorced	0.00	1.25
Bamileke	47.50	26.25	Civil servant	15.00	10.00	Married	32.50	31.25
Banen	0.00	2.50	Driver	2.50	2.50	Single	15.00	13.75
Bassa	0.00	3.75	Jobless	0.00	1.25	Widow	2.50	3.75
Bakossi	0.00	2.50	Retired	5.00	10.00			
Bayangi	0.00	1.25	Student	5.00	3.75			
Beti	0.00	1.25	Trader	6.25	8.75			
Diziga	0.00	1.25						
Mbam	0.00	2.50						
Mbo	0.00	1.25						
Moudang	0.00	1.25						
Mundini	000	1.25						
Nkambe	2.50	2.50						
Yabassi	0.00	1.25						

Market interviews

(Number of participants = 32: 9 men; 23 women); age (mean ± SD): 52.1 ± 10.9 years

Ethnicities	Bafoussam (%)	Douala (%)	Level of education	Bafoussam (%)	Douala (%)
Bamileke	50.00	40.63	Primary education	25.93	18.52
Ewondo	0.00	3.13	Secondary education	22.22	29.63
O'shie	0.00	6.25	Unschooled	0.00	3.70

Restaurant interviews

(Number of participants =16: 0 men. 16 women); age (mean ± SD): 40.9 ± 8.7 years

Ethnicities	Bafoussam (%)	Douala (%)	Level of education	Bafoussam (%)	Douala (%)
Akum	0.00	12.50	Primary education	26.67	40.00
Bamileke	37.50	18.75	Secondary education	20.00	6.67
Banso	6.25	0.00	Higher education	0.00	6.67
Bassa	0.00	6.25			
Bulu	6.25	6.25			
Mamfe	0.00	6.25			

Journal of The Science of Food and Agriculture published by John Wiley & Sons Ltd on behalf of Society of Chemical Industry.

Consumers were then asked to select the quality characteristics that better described each boiled plantain sample, among a list of 24 sensory/perception characteristics collected during previous works[14] using a 'Check-All-That-Apply' (CATA) approach. The CATA attributes included:

(Sensory descriptors)	(Perception descriptors)
Deep yellow color	Smooth
Yellow color	Absence of spaces between grains
Like ripe plantain	Tender
Good plantain odor	Mealy
Soft	Well cooked
Firm Plantain	Crunchy
Sweet taste	Too humid
Juicy (taste)	Not well cooked
Pale color	Immature plantain
Too soft	
Sticky	
Hard	
Taste of sap	
Bitter taste	
Plantain taste	

The order of appearance of JAR and CATA attributes was not the same for the consumer testing participants. Interviews were conducted in English, French, Pidgin-English, or the local language (with the help of a translator at times) and the score sheets and questionnaires were in French. Consumers were assisted by trained enumerators when required. Each interview lasted for approximately 30 min.

Statistical analyses

The qualitative data were analyzed in Excel using verbatim transcription, followed by descriptive analysis and weighing of features.[11] The robustness of the traits indicated by respondents was tested by comparing the similarity/synonymy of verbatim terms used by respondents or transcribed by different interviewers (variation in vocabulary). Important and robust qualities were chosen and prioritized based on the ranking order or citation weighting, as appropriate. A one-way analysis of variance (ANOVA) and multiple pairwise comparisons were applied using Tukey's test with a confidence interval of 95% at $P < 0.05$ were carried out to identify significant differences in overall liking scores between the boiled plantain samples as tested by the 300 consumers. Segmentation was conducted through hierarchical cluster analysis (Ward's method) to separate consumers into groups with similar acceptance levels. For each boiled plantain sample, the number of consumers who judged each specific characteristic either *just about right* (JAR), *too weak* (TW), or *too strong* (TS) was counted, and the percentage of consumers was thus determined. Penalty analysis, as defined by Gere *et al*., was used to determine possible consumer orientations based on the five sensory attributes that were chosen.[22] The JAR and overall liking scores of all boiled yam samples were combined to determine important mean reductions in overall liking when the

Table 2. Quality characteristics of raw unripe plantain, from focus group discussions

Quality type	Douala	Bafoussam	Women	Men
Poor quality	Small fruits size (15)	Large amount of sap (8)	Large amount of sap (12)	Small fruits size (12)
	Large amount of sap (11)	White pulp (7)	Apex not black (9)	Large amount of sap (7)
	Soft fruit (8)	Dried fruits (7)	Soft fruit (7)	Soft fruit (5)
	Thick peel (4)	Apex not black (6)	Small fruits size (4)	White pulp (5)
	Apex not black (3)	Soft fruit (4)	Dried fruits (3)	Dried fruits (5)
		Fruit too hard (3)	Thick peel (2)	Overripe fruit (3)
		Overripe fruit (3)	White pulp (2)	Fruit too hard (3)
		Black spots on fruit peel (2)		Black spots on fruit peel (2)
		Small fruits size (1)		Thick peel (2)
Good quality	Long and large fruits (9)	Long and large fruits (10)	Long and large fruits (11)	Semi-ripe fruits (9)
	Heavy bunch (9)	Dark green peel color (9)	Heavy bunch (9)	Long and large fruits (8)
	Reddish, orange or cream pulp (7)	Mature fruit (7)	Dark green peel color (9)	Black apex of fruits (7)
	Fruit hard on touching (6)	Pale pink pulp color (6)	Pulp pale pink, reddish, orange, cream (8)	Heavy bunch (6)
	Lime green or dark green peel color (4)	Heavy bunch (6)	Hard fruit (5)	Orange or cream pulp color (5)
	Semi-ripe fruits (3)	Black apex of fruits (6)	Black apex of fruits (5)	Mature fruit (5)
	Black apices (3)	Semi-ripe fruit (4)	Small amount of sap (3)	Lime green or dark green peel color (4)
	Small amount of sap (3)	Slightly soft fruit (3)	Healthy fruits (2)	Slightly soft fruit (3)
	Healthy fruits (2)	Small amount of sap (2)	Absence of black spots on fruit peel (2)	Healthy fruits (2)
		Healthy fruits (2)		Small amount of sap (2)
		Absence of black spots on fruit peel (2)		

Note: Numbers in brackets represent the weighted scores.

Journal of The Science of Food and Agriculture published by John Wiley & Sons Ltd on behalf of Society of Chemical Industry.

Table 3. Quality characteristics of unripe boiled plantain identified by focus group discussions

Quality type	Douala	Bafoussam	Women	Men
Poor quality	Hard plantain (18)	Sticky in the mouth (16)	Hard plantain (16)	1. Hard plantain (16)
	Sticky in the mouth (9)	Hard plantain (14)	Sticky in the mouth (12)	2. Glue in the mouth (13)
	Not scraped (8)	Not scraped (7)	Dark yellow, light yellow, white pulp color (9)	3. Not scraped (5)
	White, light yellow or dull pulp color (9)	Dark yellow, light yellow, white or black pulp color (6)	Not scraped (8)	4. Bland taste (3)
	White or brown spots inside the pulp (1)	Bland taste (5)	Dull pulp color (not bright) (4)	4. Not sweet when ripe (3)
	Not sweet when ripe (1)	Dry plantain (2)	Bland taste (2)	6. White or pale yellow pulp color (2)
		Not sweet when ripe (2)	White or brown spots inside the pulp (1)	6. Dry (2)
		Bitter plantain (2)		6. Bitter (2)
Good quality	Soft plantain (15)	Soft plantain (22)	Soft plantain (20)	Soft plantain (17)
	Brown, golden, yellow pulp color (13)	Smooth (14)	Yellow, brown or cream pulp color (15)	Golden, yellow, or reddish pulp color (11)
	Smooth (6)	Yellow pulp color (13)	Smooth (9)	Smooth (11)
	Lack of sap (6)	Lack of sap (4)	Lack of sap (5)	Lack of sap (5)
	Mealy (2)	Wet (must contain enough water) (2)	Wet (must contain enough water) (2)	Mealy (2)
	Sweet (2)	Tasty (1)	Good smell (1)	Sweet (2)
	Good smell (1)		Tender (1)	Tasty (1)
	Tender (1)			

Note: Numbers in brackets represent the weighted scores.

Table 4. Quality criteria related to users of raw unripe plantain obtained from focus group discussions through different participants in the plantain value chain

Producers	Traders	Processors	Consumers
Long and large fruits (8)	Mature fruit (21)	Mature fruit (16)	Long and large fruits (19)
Heavy plantain bunch (6)	Long and large fruits (15)	Thin peel (13)	Heavy plantain bunches (15)
Mature fruit (5)	Black apex of fruits (9)	Long and large fruits (11)	Lime green or dark green peel color (13)
Healthy fruits (2)	Heavy plantain bunch (6)	Small amount of sap (3)	Pale pink, reddish, orange or cream pulp color (13)
	Healthy fruits (3)		Semi-ripe fruit (9)
	Fruit hard on touching (3)		Costs of bunch (9)
	Absence of black spots on the skin (2)		Fruit hard on touching (8)
			Mature fruit (5)
			Healthy fruits (4)

Note: Numbers in brackets represent the weighted scores.

characteristics were rated TW or TS by at least 20% of consumers (Pareto principle).[23] When ranking some variables, the overall frequency of citations, obtained by summing the frequency of citations multiplied by their corresponding coefficients, was used as a means of differentiation. As such, the first choice had a coefficient of 3, the second choice had a coefficient of 2, and the third choice a coefficient of 1. Statistical analyses were performed using XLSTAT 2014 software.[24]

RESULTS

Gendered food mapping

Socio-demographic characteristics of survey participants

The socio-demographic characteristics of the participants revealed that the Bamileke ethnic group represented between 55% and 90% of participants in focus group discussions (FGDs), IIs, MIs, and RI. Participants in FGDs were mostly students, and the majority of those in IIs were artisans (tailor, carpenter, etc.). The MI and RI participants attained 'primary education' (44.5 and 66.67%) and 'secondary education' (51.9 and 26.7%). The majority of the participants in II were married (Table 1).

Plantain quality characteristics

Raw plantain quality characteristics

Plantain characteristics that define a crop as poor or good quality were assessed in each town and according to gender (Table 2). The predominant raw plantain characteristics for a poor crop are *small fruit size*, *large amount of sap*, *apex not black*, and *soft fruit*; meanwhile raw plantain characteristics for a good crop include *long and large fruits*, *heavy bunch*, *mature fruit*, *orange pulp color*.

Boiled plantain quality characteristics

Boiled plantain quality characteristics were classified according to urban area and gender. The least preferred qualities of boiled plantain included *hard plantain*, *sticky plantain*, *dull pulp color*, *not scraped*, *bitter*; meanwhile high-quality characteristics include: *soft plantain*, *yellow pulp color*, *smooth*, *lack of sap* (Table 3).

Quality characteristics per stakeholder

The quality characteristics of a good plantain according to the participants in the plantain sector are summarized in Table 4. The most preferred quality criteria by the various stakeholders included: mature fruit, healthy fruit, and long and large fruits.

Consumer testing

Socio-demographic characteristics of the consumers

Among the 300 consumers interviewed, about half were women. Most of these consumers were aged between 26 and 35 years. Artisanship was the main occupation of these consumers, followed by the category 'employed'. Bamileke was the most represented ethnicity, followed by Bassa. The majority of these consumers had attended secondary schools and were married. Plantain is mostly eaten in the boiled form. Fried plantain is the second form of plantain consumption in the research areas. About 40% of the participants consumed boiled plantain several times a week, while a quarter consumed it several times a month. Only 0.7% of the consumers ate boiled plantain daily (Table 5).

Accompaniments and ripening stages of boiled plantain

Boiled plantain is eaten at various stages of ripeness with a multitude of other foods (Table 6). Based on the frequency of citation, consumers prefer eating boiled plantain with *ndole*, a Cameroonian dish consisting of stewed groundnuts, *ndoleh* (bitter leaves indigenous to West Africa), and fish or beef, followed by groundnut sauce and fried beans. Boiled plantain was most commonly consumed at the half-ripe maturity stage, followed by the ripe and unripe stages.

Overall liking of boiled plantain samples

The overall liking for the boiled plantain samples differed significantly ($P < 0.05$, one-way ANOVA) (Table 7). The most liked boiled plantain samples were the *Batard* and *Big Ebanga* samples with a mean overall liking score of 7.0 and 6.9 respectively (liked moderately). The least liked was the *CARBAP K74* sample with a mean overall liking score of 5.8 (liked slightly). The *Batard* and *Big Ebanga* samples presented significant differences in their overall liking from the *CARBAP K74* sample.

Cluster analysis of the consumer liking data

An agglomerative hierarchical clustering analysis of the mean overall liking scores enabled the identification of three groups of consumers that we named *Batard* and *Big Ebanga* likers, *All likers* and *Neither likers nor dislikers* (Table 5). These three clusters were significantly different in their overall liking scores ($P < 0.001$) (Fig. 3(A),(B)). The third cluster contains *Batard* with an overall

Table 5. Demographic differences of the consumers with respect to cluster division

Quality type	Total	Cluster 1 (BTD and BEG likers)[a]	Cluster 2 (all likers)	Cluster 3 (neither likers nor dislikers)
Number of consumers	**300**	**54.30%**	**24.00%**	**21.70%**
Region				
West (%)	50.0	55.3	23.3	21.3
Littoral (%)	50.0	53.3	24.67	22.00
Gender				
Women (%)	49.7	57.7	24.2	18.1
Men (%)	50.3	51.0	23.9	25.2
Age				
18–25 years old (%)	16.7	48.0	24.0	28.0
26–35 years old (%)	30.0	54.4	21.1	24.4
36–45 years old (%)	19.7	55.9	27.1	17.0
46–55 years old (%)	18.7	69.6	12.5	17.9
≥56 years old (%)	15.0	40.0	40.0	20.0
Ethnicity				
Bamileke (%)	59.3	53.4	24.2	22.5
Bassa (%)	20.7	62.9	19.4	17.7
Bamenda (%)	3.3	50.0	30.0	20.0
Beti (%)	2.0	33.3	16.7	50.0
Essimbi (%)	2.3	14.3	71.4	14.3
Mbo (%)	2.7	50.0	25.0	25.0
Sawa (%)	1.7	40.0	20.0	40.0
Northerner (%)	1.0	100.0	0.0	0.0
Bafia (%)	1.7	100.0	0.0	0.0
Others (%)	5.3	43.8	31.3	25.00
Education				
No education (%)	1.7	40.0	20.0	40.0
Primary education (%)	20.7	50.0	30.7	19.4
Secondary education (%)	54.7	57.9	23.8	18.3
Higher education (%)	23.0	50.7	18.8	30.4
Marital status				
Single (%)	35.7	56.1	19.6	24.3
Married (%)	60.7	54.4	26.4	19.2
Widower (%)	3.7	36.4	27.3	36.4
Occupation				
Student (%)	14.3	51.2	11.6	37.2
Artisanship (%)	36.7	53.6	21.8	24.6
Civil servant (%)	1.3	75.0	25.0	0.0
Trading business (%)	12.7	44.7	39.5	15.8
Employed (%)	21.0	57.1	25.4	17.5
Unemployed (%)	12.0	63.9	27.8	8.3
Retired (%)	2.0	50.0	16.7	33.3
Frequent consumption form				
Boiled plantain (%)	63.0	52.9	21.2	25.9
Roasted plantain (%)	6.0	38.9	38.9	22.2
Pounded plantain (%)	7.3	72.7	22.7	4.6
Fried plantain (%)	23.7	56.3	28.2	15.5
Consumption frequency				
Daily (%)	0.7	50.0	0.0	50.0
Several times a week (%)	38.3	60.0	20.9	19.1
One time a week (%)	21.7	53.9	26.2	20.0
Several times a month (%)	26.0	47.4	30.8	21.8
One time a month (%)	13.3	52.5	17.5	30.0

[a] BTD = *Batard*; BEG = *Big Ebanga*.

liking of 5.32, *CARBAP K74* with an overall liking of 4.95 and *Big Ebanga* with an overall liking of 4.55, hence corresponding to 'neither like nor dislike'.

Just-about-right test

A 3-point JAR scale was used to determine the optimum level of intensity as perceived by the consumers for color, texture in the

Table 6. Preferred accompaniments and ripening stages for boiled plantain

Criteria	Accompaniment/ Ripening stage	Frequency of citations: First choice/form (Coef. 3)	Second choice/form (Coef. 2)	Third choice/form (Coef. 1)	Overall frequencies of citations[a]
Accompaniments/ sauces	With fried beans	31	50	54	247
	With fried eggs	5	17	26	75
	With pepper soup	34	33	45	213
	With *'Ndole'*	108	64	43	495
	With groundnut sauce	42	45	41	257
Ripening stage	Unripe	80	69	86	464
	Half-ripe	115	128	20	621
	Ripe	103	62	76	509
	Overripe	2	5	9	25

Abbreviation: Coef., Coefficient.
[a] Obtained by summing the frequencies of citations multiplied by their corresponding coefficients for each row.

Table 7. Mean overall liking scores for the three boiled plantain samples tested

Boiled plantain samples	Mean overall liking scores[a] (300 consumers)	Groups[b]
Batard	7.0	A
Big Ebanga	6.9	A
CARBAP K74	5.8	B

[a] Overall liking was rated on a 9-point scale from 1 = dislike extremely, to 9 = like extremely.
[b] Different letters correspond to significant differences between the products. Tukey test ($P < 0.05$).

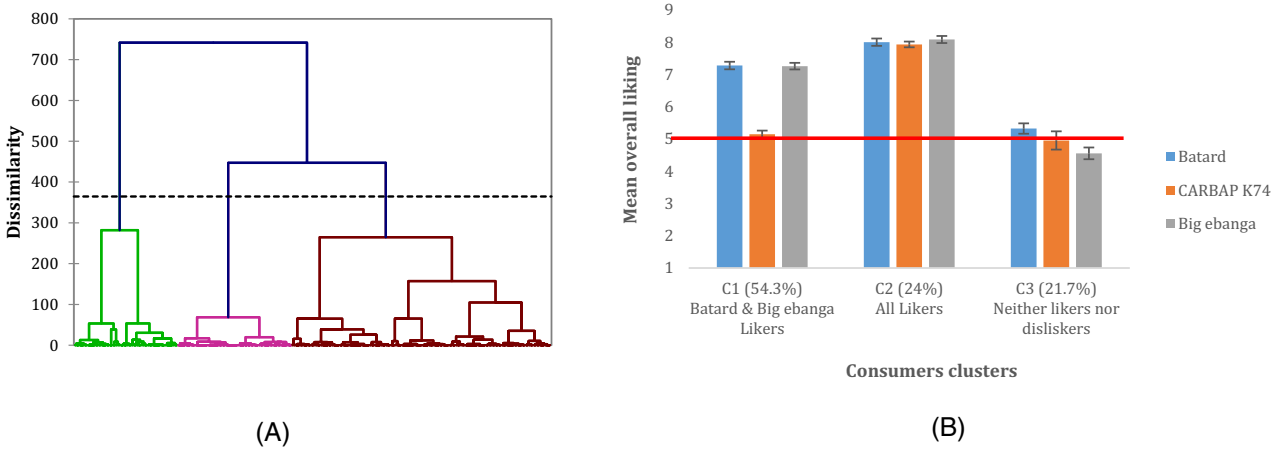

Figure 3. Clustering of the consumers based on their overall liking scores (A) and mean overall liking (B) of the boiled plantain samples by consumer cluster type.

mouth, sweet taste, and humidity (in the mouth) of boiled plantain samples (Fig. 4). Such descriptor diagnostics may help to explain why consumers like or dislike a particular boiled plantain sample. Most consumers were satisfied with the four sensory characteristics of *Batard* and *Big Ebanga* boiled plantain samples. Color, sweet taste, texture in the mouth and humidity were scored JAR by more than 60% of consumers. On the other hand, the color of *CARBAP K74* boiled plantain sample was perceived as too clear by 39.7% of consumers, and 62.7% of participants perceived the taste as not sweet. This sample was also perceived as too soft, too humid, and too clear color, by less than 40% of the consumers. However, more than 50% of the consumers found the texture and humidity of CARBAP K74 boiled plantain just about right.

Check-all-that-apply test

The objective of the CATA test was to show the relationships between hedonic overall liking scores for each boiled plantain

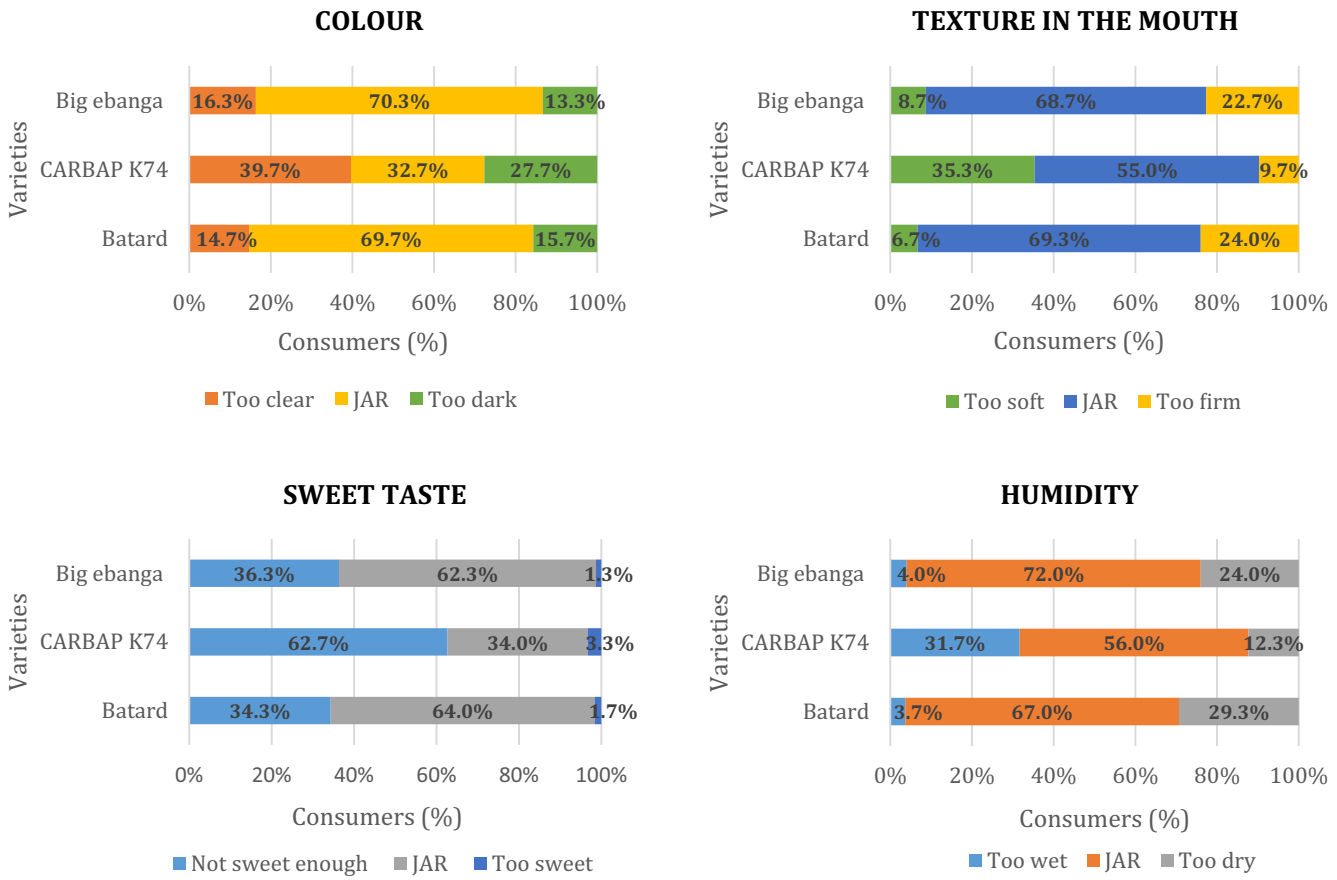

Figure 4. Percentage of consumers who scored the four specific quality characteristics.

sample and the frequencies of citation of each CATA sensory characteristic by all the consumers. A total of 900 responses (300 individuals and three samples) was expected. After scoring the overall liking and the perception of some specific sensory characteristics, consumers were invited to choose the most appropriate terms among 24 sensory characteristics that better describe each boiled plantain sample. The frequency of citations given by consumers to describe each boiled plantain sample was calculated (Table 8). The sensory characteristics most frequently cited by the consumers were considered the best for describing boiled plantains. They were the following: well cooked, plantain taste, good plantain aroma, and smooth with a frequency of citation between 800 and 650, followed by firm plantain, mealy, yellow, and tender with a frequency of citation between 600 and 400. The least used terms were bitter, too soft and too humid. The *Batard* boiled plantain sample was described as well-cooked by consumers, smooth, firm, mealy, with a good plantain aroma and a plantain taste. Consumers used the same characteristics to describe the boiled pulps of *Big Ebanga* with almost the same frequencies of citation. The *CARBAP K74* boiled plantain sample was qualified as soft, immature, with absence of spaces between grains, a taste of sap, and a pale color. It was, however, perceived as well cooked, and smooth, with a plantain taste like the two other boiled plantain samples.

Penalty analysis

In order to evaluate the significant mean decline in consumer acceptance associated with a change from one characteristic to another, penalty analysis was employed in conjunction with overall acceptability and its corresponding JAR. The penalties corresponding to significant mean decrease in liking for each sweetener are indicated in Table 9. Two 'Not-JAR' categories, too weak (tw) and too strong (ts), might apply to all the qualities for each variety. With the exception of the attribute sweet taste, which was significantly penalized by the variety Big Ebanga, all of the varieties significantly penalized these attributes.

DISCUSSION

The socio-demographic data on participants in this study are consistent with the findings of Dury *et al.*,[25,26] who included participants from different ethnic and cultural backgrounds in their research. Our results revealed that the majority of the people surveyed were doing artisanal work because of their availability. Plantain users are mostly individuals who run households and have a stable marital status. Participants surveyed in the markets and restaurants had mostly a primary or secondary education. This was in line with the results obtained by Foléfack *et al.*,[27] who found that the majority of people in the Douala plantain supply chain had completed their primary and secondary schooling.

Poor quality characteristics of raw plantain are recognized by its shape, texture, level of ripeness, and sap content (Table 2). These criteria can be observed in raw plantain or during processing and enable the identification of good-quality plantain. The least appreciated characteristics of raw plantain obtained in this study

Journal of The Science of Food and Agriculture published by John Wiley & Sons Ltd on behalf of Society of Chemical Industry.

Table 8. Frequency of citations of each quality characteristic by all the individuals in the consumer testing study

Quality characteristics	*Batard*	CARBAP K74	*Big Ebanga*	Total number of citations
Hard	86	31	68	185
Sweet	114	47	100	261
Sticky	130	104	110	344
Pale color	54	107	49	210
Plantain taste	283	171	281	735
Deep yellow	113	105	102	320
Tender	151	115	145	411
Juicy	79	93	91	263
Firm plantain	227	119	224	570
Good plantain aroma	271	156	274	701
Too humid	5	73	4	82
Not well cooked	40	46	44	130
Immature plantain	33	137	41	211
Too soft	5	67	5	77
Like ripe plantain	113	51	117	281
Yellow	162	98	169	429
Soft	96	149	110	355
Mealy	203	109	205	517
Well cooked	258	248	248	754
Smooth	241	217	236	694
Absence of spaces between grains	112	140	80	332
Crunchy	32	58	38	128
Taste of sap	55	120	59	234
Bitter	2	6	1	9
Mean overall liking	**7.0**	**5.8**	**6.9**	

Table 9. Penalty analysis results summary of mean decrease in overall liking (based on a 9-point scale) and percentage of not just-about-right (JAR) evaluations for boiled plantain samples

	Penalty category[a]							
	Color		Sweet taste		Texture in the mouth		Humidity	
Plantain varieties	Mean decrease	Not JAR, %	Mean decrease	Not JAR, %	Mean decrease	Not JAR, %	Mean decrease	Not JAR, %
Batard	tw:0.8*; ts:0.6*	tw:14.7; ts:15.7	tw:1.2; ts:1.0	tw:34.3; ts:1.7	tw:1.1*; ts:1.4*	tw:6.7; ts:24.0	tw:1.3*; ts:1.2*	tw:29.3; ts:3.7
CARBAP K74	tw:0.8*; ts:1.2*	tw:39.7; ts:27.7	tw:1.1; ts:0.5	tw:62.7; ts:3.3	tw:1.3*; ts:1.0*	tw:35.3; ts:9.7	tw:1.0*; ts:1.3*	tw:12.3; ts:31.7
Big Ebanga	tw:1.0*; ts:0.8*	tw:16.3; ts:13.3	tw:1.5*; ts:2.2*	tw:36.3; ts:1.3	tw:1.0*; ts:1.3*	tw:8.7; ts:22.7	tw:1.4*; ts:1.7*	tw:24.0; ts:4.0

[a] tw = too weak; ts = too strong.
*$P < 0.05$ (significant mean decrease in overall liking based on Tukey test).

have been listed previously.[14,28] These include immature bunches, fruits affected by ecchymosis, and fruits gnawed by pests, as plantain users pay particular attention to the ripeness and healthiness of raw plantain.[13] The most appreciated characteristics of raw plantain are in agreement with previous reports.[13,14,28] This study indicated that, in general, urban end users had similar preferences to those at the rural level.

Concerning the attributes that were not wanted in boiled plantain, this study corroborates earlier findings.[14] Moreover, the least preferred characteristics of boiled yam included similar characteristics such as a color that is too dark, hardness to the touch, and no sweet taste.[29] This is because people are sensitive to the impact of cooking and storage of boiled roots and tubers. Now, there is evidence that consumers from both urban and rural areas appreciate the quality of boiled plantain based on the appearance, flavor and texture in the mouth as well as the smell. To appeal to consumers, boiled plantain must therefore be attractive, appetizing, and have a pleasant smell and taste.

In Cameroon, the plantain value chain is made of producers, traders, processors, and consumers. The different participants in the plantain sector have various criteria to attest the quality of raw plantain (Table 3). However, depending on the type of stakeholder, the quality characteristics of plantains fall within a specific framework.[13] For producers, plantain quality attributes must be in favor of high production yields, and plantains must therefore have heavy bunches, with mature, healthy, long, and large fruits. Plantain growers also prefer plantain varieties that are highly resistant to diseases and pests. In the case of traders, the quality characteristics of plantains are related to their market value; meanwhile, the processors are more interested in the ease of processing plantains and their involvement in the preparation of the products. Indeed, processors want plantain varieties that are easy to process (short

peeling and cooking times), with mature, long, and large fruits, containing a small amount of sap and with a thin peel. Consumers are concerned about food safety and costs. They want plantains that are attractive, tasty, and pleasant to eat. Consumers also prefer plantains that are cheaper and will not endanger their health.

Boiled plantain is consumed at various ripening stages with the half-ripe stage being the preferred stage as found by Udomkun *et al.*,[8] for whom 46.6% of consumers were found to prefer this ripening stage over the unripe, ripe, and overripe stages. Moreover, the results of the present study confirm the findings of Udomkun *et al.*[8] who reported that boiled plantains are more frequently consumed weekly rather than monthly.

Batard and *Big Ebanga* were moderately appreciated; meanwhile *CARBAP K74* was less appreciated. Some panelists said that *CARBAP K74* tastes like boiled dessert bananas. These results corroborate the reported preference of landraces over improved hybrids by consumers.

The panelists' contentment with the four sensory attributes (color, sweet flavor, texture, and humidity) of boiled Batard and Big Ebanga stems from their inherent plantain nature. This is not the case with boiled *CARBAP K74*, whose sensory characteristics were more similar to those of a dessert banana than a plantain, to the dissatisfaction of consumers. Most of the 24 sensory characteristics were attributed almost as many times to *Batard* and *Big Ebanga* because they all express plantain's typical characteristics. As found in this study, the most appreciated characteristics of boiled plantain are yellow pulp, good plantain aroma, the taste of plantain, and sweet taste.[13] Undesirable characteristics identified in the present study are similar to those from Nigeria: too soft, burnt, not well cooked, sticky, immature plantain, bad taste, and bad smell.[28] Nevertheless, the panelists were accustomed to consuming half-ripe or ripe boiled plantains, so the unripe form they were offered was unusual for them, which is why they found boiled *Batard* and *Big Ebanga* hard.

The characteristic 'hardness', deemed as a poor-quality feature, was rather related to the most liked boiled plantain samples (*Batard* and *Big Ebanga*) instead of the least liked boiled plantain sample (*CARBAP K74*). Despite the difficulty observed when chewing the landraces, the other characteristics overcome their 'hardness', hence making it acceptable to consumers. The participants mostly consumed half-ripe or ripe plantain, which is less hard than unripe plantain.

The descriptors 'tw-sweet taste', 'ts-humidity', 'tw-color' and 'tw-texture in the mouth' received the highest mean decreases in overall liking scores. The CATA test revealed that the characteristics *pale color* and *soft* were among the most cited negative characteristics by all the consumers to describe *CARBAP K74*. Similarly, the JAR test showed that these characteristics penalize overall liking.

Limitations and suggestions

The results are likely to represent the survey areas, notably the eating habits and plantain varieties grown. The number of plantain samples examined during consumer testing is very likely inadequate to capture sufficient detail regarding quality features. The change in sensory quality along the proximal, middle, and distal portions of the plantain fruit should be taken into consideration while distributing samples to consumers.

CONCLUSION

This study aimed to assess criteria that guide the choice of plantain by end users in urban and rural areas. It can now be concluded that quality characteristics of plantain, as well the acceptability of boiled plantains, are the same in rural and urban areas. Raw plantain bunches should bear long and large fruits and mature fruits with an orange pulp color, whereas boiled plantain pulps should be soft, smooth, with a yellow pulp color. The plantain-like hybrid *CARBAP K74* was on par with the local landraces on most attributes, except for sweet taste and color. Plant breeders should therefore emphasize improving these attributes to promote the adoption of newly created hybrids. The optimal point for harvesting and the optimal storage conditions of plantains should also be investigated.

AUTHOR CONTRIBUTIONS

Conceptualization: Gérard Ngoh Newilah and Geneviève Fliedel. Data curation: Cédric Kendine Vepowo, Raymonde Nya Nzimi, and Cédric Kuate Kengne. Formal analysis: Gérard Ngoh Newilah and Cédric Kendine Vepowo. Funding acquisition: Didier Mbeguie-A-Mbeguie and Gérard Ngoh Newilah. Investigation: Gérard Ngoh Newilah, Cédric Kendine Vepowo, Annie Takam Ngouno, Claudin Karim Nana, Vivien Meli Meli, Raymonde Nya Nzimi and Cédric Kuate Kengne. Methodology: Gérard Ngoh Newilah, Geneviève Fliedel and Didier Mbeguie-A-Mbeguie. Project administration: Gérard Ngoh Newilah. Resources: Gérard Ngoh Newilah. Supervision: Dominique Dufour and Inocent Gouado. Writing – original draft: Cédric Kendine Vepowo, Cédric Kuate Kengne, and Raymonde Nya Nzimi. Writing – review and editing: Cédric Kendine Vepowo, Gérard Ngoh Newilah, Annie Takam Ngouno, Claudin Karim Nana, Vivien Meli Meli, and Didier Mbeguie-A-Mbeguie.

ACKNOWLEDGEMENTS

In memoriam of our colleague and friend Geneviève Fliedel, PhD, food technologist at CIRAD who contributed to this work and for the passion and enthusiasm that characterized her work as a researcher. This work was carried out under a CARBAP-CIRAD Partnership Contract within the framework of project 2019–2021 CRP-RTB, signed on 2 October, 2019. Cluster CC4.1: 'Post-harvest innovation and nutrition improvement' and supported the grant opportunity INV-008567 (formerly OPP1178942): Breeding RTB Products for End User Preferences (RTBfoods), to the French Agricultural Research Centre for International Development (CIRAD), Montpellier, France, by the Bill & Melinda Gates Foundation (BMGF): https://rtbfoods.cirad.fr. Previous versions of this paper and the ideas in it benefited greatly from suggestions and comments by Ngondi Judith, Fokou Elie, and Etoa François-Xavier. The editorial comments by Hernán Ceballos and Dominique Dufour as well as the final proofreading of the manuscripts by Clair Hershey improved the quality of this manuscript greatly. The valuable suggestions and corrections by reviewers also contributed significantly to the quality of this article.

ETHICS STATEMENT

The research described in this manuscript (from laboratory through consumer preferences interviews and surveys) has been approved by the National Ethics Committee for Human Health Research in Cameroon. Written informed consent was obtained for all studies participants and is available.

CONFLICT OF INTEREST

The authors declare no conflict of interest in this work.

Journal of The Science of Food and Agriculture published by John Wiley & Sons Ltd on behalf of Society of Chemical Industry.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

REFERENCES

1 De Langhe E, Diversity in the genus Musa its significance and its potential. *Acts Horticultural* **54**:81–88 (2000).
2 Bhat KV, Amaravathi Y, Gautam PL and Velayudhan KC, AFLP characterization and genetic diversity analysis of Indian banana and plantain cultivars (Musa spp). *Plant Genetic Resources* **2**:121–130 (2009).
3 Dzomeku B, Darkey S, Bam R and Ankomah A, Sensory evaluation of four FHIA tetraploid hybrids for Kaakle (a local dish) in Ghana. *J Plant Sci* **2**:640–643 (2007a).
4 FAOSTAT [WWW Document] (2020). http://www.fao.org, http://www.fao.org/faostat/en/#data/QC [25 March 2021].
5 Ngoh Newilah GB, Tchango TJ, Fokou E and Etoa F-X, Processing and food uses of bananas and plantains in Cameroon. *Fruits* **60**:245–253 (2005). https://doi.org/10.1051/fruits:2005031.
6 Ngoh Newilah GB, Manjia Ngoungoure SU, Tembe J *et al*., Physicochemical and nutritional values of some recipes made of bananas and plantains consumed in the east region of Cameroon. Greener journal of. *Agric Sci* **8**:30–41 (2018). https://doi.org/10.15580/GJAS.2018.2.011318005.
7 Kouamé CA, Kouassi NK, N'dri DY and Amani GNG, 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. *Nat. technol* **12**:115 (2015).
8 Udomkun P, Masso C, Swennen R, Innawong B, Fotso KA, Alakonya A *et al*., Consumer preferences and socioeconomic factors decided on plantain and plantain-based products in the central region of Cameroon and Oyo state, Nigeria. *Foods* **10**:1955 (2021).
9 Eriksson D, Akoroda M, Azmach G, Labuschagne M, Mahungu N and Ortiz R, Measuring the impact of plant breeding on sub-Saharan African staple crops. *Outlook Agric* **47**:163–180 (2018).
10 Tenkouano A, Lamien N, Agogbua J, Amah D, Swennen R, Traoré S *et al*., Promising high-yielding tetraploid plantain bred-hybrids in West Africa. *Int J Agron* **8**:1–8 (2019). https://doi.org/10.1155/2019/3873198.
11 Forsythe L, Tufan H, Bouniol A, Kleih U and Fliedel G, An interdisciplinary and participatory methodology to improve user acceptability of root, tuber and banana varieties. *Int J Food Sci Technol* **56**:1115–1123 (2021). https://doi.org/10.1111/ijfs.14680.
12 Ortiz R and Swennen R, From crossbreeding to biotechnology-facilitated improvement of banana and plantain. *Biotechnol Adv* **32**:158–169 (2014).
13 Marimo P, Caron C, Van den Bergh I *et al*., Gender and trait preferences for banana cultivation and use in sub-Saharan Africa: a literature review. *Econ Bot* **74**:226–241 (2020).
14 Ngoh Newilah GB, Kendine Vepowo C, Takam Ngouno A *et al*., Analysis of consumer-oriented quality characteristics of raw and boiled plantains in Cameroon: implication for breeding. *Int J Food Sci Technol* **56**:1135–1147 (2021). https://doi.org/10.1111/ijfs.14812.
15 Lawless HT and Heymann H, *Sensory Evaluation of Food: Principles and Practices*. Springer New York, New York, NY (2010 [cited 16 march 2021]. (Food Science Text Series)) Available at. http://link.springer.com/10.1007/978-1-4419-6488-5.
16 Kihinga TJ, *Consumer Preference and Acceptability for Sweet Potato Varieties in the Lake Zone of Tanzania*. University of Agriculture, Morogoro (2007).
17 Siegrist M and Hartmann C, Consumer acceptance of novel food technologies. *Nat Food* **1**:343–350 (2020). https://doi.org/10.1038/s43016-020-0094-x.
18 Sanya LN, Sseguya H, Kyazze FB, Diiro GM and Nakazi F, The role of variety attributes in the uptake of new hybrid bananas among smallholder rural farmers in Central Uganda. *Agric Food Secur* **9**:1–13 (2020).
19 Kamdem MJD, *Developing Sensory Evaluation Methods for Consumers with Low Literacy Levels Applicable in Developing Countries*. University of Pretoria, MSc Food Science, Pretoria (2016).
20 Forsythe L, Fliedel G, Tufan H and Kleih U, *RTBfoods Step 2: Gendered Food Mapping*. CIRAD-RTBfoods Project, Montpellier, France, p. 74 (2018). https://doi.org/10.18167/agritrop/00569.
21 Fliedel G, Kleih U, Bechoff A and Forsythe L, *RTBfoods Step 4: Consumer Testing in Rural and Urban Areas*. CIRAD-RTBfoods Project, Montpellier, France, p. 29 (2018). https://doi.org/10.18167/agritrop/00571.
22 Gere A, Szabo Z, Pasztor-Huszar K, Orban C, Kokai Z and Sipos L, Use of JAR-based analysis for improvement of product acceptance: a case study on flavored kefirs. *J Food Sci* **82**:1200–1207 (2017).
23 Meullenet JF, Xiong R and Findlay CJ, *Multivariate and Probabilistic Analyses of Sensory Science Problems*. John Wiley & Sons, Hoboken, New Jersey - USA, (2008).
24 XLSTAT Version 2014.5.03 Copyright Addinsoft 1995–2014. XLSTAT and Addinsoft are Registered Trademarks of Addinsoft (2014). https://www.xlstat.com.
25 Dury S, Bricas N, Tchango J, Temple L and Bikoï A, La consommation et les critères de qualité du plantain à Douala et Yaoundé, in *Les productions bananières: un enjeu économique majeur pour la sécurité alimentaire (Pp. 507–523)*. International Symposium, Douala, Cameroon, 10–14 November 1998 = Bananas and food security $ENG. INIBAP, CRBP, CTA, CIRAD. Montpellier: INIBAP. ISBN 2–910810–36-4 Symposium international les productions bananières, Douala, Cameroun, 10 Novembre 1998/14 Novembre 1998, ed. by Picq C, Fouré E and Frison E (dirs). INIBAP, Montpellier, France (1999).
26 Dury S, Bricas N, Tchango Tchango J, Temple L and Bikoï A, The determinants of urban plantain consumption in Cameroon. *Food Qual Prefer* **13**:81–88 (2002).
27 Foléfack DP, Fongang FGH, Adamou KM, Ebongue JP, Bikoï A and Noupadja P, Analysis of the plantain supply system of Markets in the City of Douala. *J Econ Sustain Dev* **8**:141–158 (2002).
28 Amah D, Stuart E, Mignouna DB, Swennen R and Teeken B, End-user preferences for plantain food products in Nigeria and implications for genetic improvement. *Int J Food Sci Technol* **56**:1–12 (2020). https://doi.org/10.1111/ijfs.14780.
29 Honfozo L, Adinsi L, Bouniol A, Adetonah S, Forsythe L, Kleih U *et al*., Boiled yam end-user preferences and implications for trait evaluation. *Int J Food Sci Technol* **56**:1447–1457 (2021). https://doi.org/10.1111/ijfs.14707.