Laboratory Standard Operating Procedure

Sensory Evaluation of Boiled Plantain

Biophysical Characterization of Quality Traits, WP2

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Ethics: The activities, which led to the production of this manual, were assessed and approved by the CIRAD Ethics Committee (H2020 ethics self-assessment procedure). When relevant, samples were prepared according to good hygiene and manufacturing practices. When external participants were involved in an activity, they were priorly informed about the objective of the activity and explained that their participation was entirely voluntary, that they could stop the interview at any point and that their responses would be anonymous and securely stored by the research team for research purposes. Written consent (signature) was systematically sought from sensory panelists and from consumers participating in activities.

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RTBfoods

WP2: Biophysical Characterization of Quality Traits

SOP: Sensory Evaluation of Boiled Plantain

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ABSTRACT

This SOP describes an objective methodology to assess the sensory quality of boiled plantain by a trained panel. After selection at the mature green stage, contrasting varieties of bananas (Musa spp.), consisting of 13 varieties of plantain, 2 cooking hybrids and 1 dessert banana (mainly from Côte d'Ivoire), served as a matrix for study. The controlled ripening of these bananas led to three stages of ripening (green, half ripe and fully ripe), which were then boiled. Subsequently, the sensory analysis of the boiled plantain was carried out at the optimum tasting temperature on the standardized samples. Based on objective acceptability criteria, a descriptive and specific vocabulary for boiled plantain has been defined. Finally, six descriptors were selected: four for texture in the mouth (firmness, chewiness, mealiness and stickiness), one for taste (sweetness) and one for impression in the mouth (moistness). The intensity of these sensory attributes was measured on a scale ranging from 0 (very weak) to 10 (very strong), except for chewiness, which was the subject of a specific measurement protocol. Moreover, given the strong influence of temperature on the sensory perception, the optimal tasting temperature of the samples was strictly monitored during the sensory evaluation using a probe connected to a thermocouple.

Keywords: quantitative descriptive analysis, plantain, boiling, ripeness stage, texture, sweetness, temperature monitoring

1 SCOPE OF THE STUDY

The aim of this SOP is to describe an objective methodology for sensory quality assessment of boiled plantain by a trained panel.

1.1 Prerequisite

RTBfoods deliverable (2018): RTBfoods Sensory Analysis Manual. Part 1: Training a panel in sensory analysis and implementing descriptive tests. Part 2: Tutorial: How to process data in sensory analysis.

2 GENERALITY ON BOILED PLANTAIN

Boiled Plantain is a dish widely consumed in the tropics. In Côte d'Ivoire, as elsewhere, this dish is obtained after boiling green and ripe plantains in water. Moreover, the sensory quality of boiled plantain is differently appreciated by consumers depending on the banana variety, the ripening stage and the cooking time. Given the importance of sensory criteria in the varietal adoption of bananas, it was therefore essential to develop an objective methodology to assess the sensory quality of boiled plantain. Ultimately, this study would make it possible to define the target sensory profile of boiled plantain.

2.1 Boiled plantain Preparation in Laboratory conditions

2.1.1 Raw material and sampling

Sixteen varieties of banana (Musa spp.) were used in this study. Bunches from twelve plantain and two hybrid (AAAB) varieties were collected at the mature green stage at Krindjabo in south-eastern Ivory Coast (5°24N; 3°13W) and Azaguié (5°38N; 4°05W) (Table 1).
After packing, fruit samples were dispatched by air to CIRAD Montpellier and stored at 14 °C until use.
Bunches from one plantain cultivar (AAB) Dominico Harton from Honduras and from one Cavendish dessert type cultivar (AAA) from Ecuador were purchased from a local fruit and vegetable store in Montpellier (France) at the mature green stage and also stored at 14 °C until use.

2.1.2 Controlled ripening Bunches

Fruits were judged to be at the mature green stage (MG), if there was no visible discoloration of the peel. Prior to storage at 20 °C with 80% humidity until used for cooking and sensory tasting, two-thirds of the mature green fruits of each cultivar underwent ethylene treatment (1 mL. L^{-1}) for 24 h to trigger the ripening process.

One-third of the mature green fruits ripened during for 4 days. Fruits presented a peel colour more yellow than green, which correspond to a half-ripe (HR) stage of ripeness. One-third of the mature green fruits were stored for 8 days. Fruits exhibited an apparent yellow peel colour, which correspond to a fully ripe (FR) stage of ripeness. Most varieties could not be assessed at all stages of ripeness, due to early ripening or inadequate availability of fruits. Eleven mature green, sixteen half-ripe and eight fully ripe samples were evaluated by panel (Table I).

Table I: List of cultivars for the study

Vernacular name	Scientific name	Type[a]	Genotype	Collection area/Country	Abbreviation	Grade (mm)	Ripening stage (quantity of products)		
							MG (11)	HR (16)	FR (8)
Cultivars used for calibration									
Afoto	-	FH	AAB	Abo/CI	af	39	-	1	1
Agnrin	Light French	F	AAB	Abo/CI	ag	29	-	1	1
Alosso	Horn 1	FH	AAB	Abo/CI	al	40	-	1	-
Big ebanga	Big ebanga	FH	AAB	Aza/CI	be	32	1	-	-
Corne 1	Horn 1	FH	AAB	Aza/CI	co	39	1	1	1
Dechair	-	FH	AAB	Abo/CI	de	29	1	1	1
Kaki	Horn 5	FH	AAB	Abo/CI	ka	29	-	2	-
Kpatregnon	-	RH	AAB	Abo/CI	kp	31	3	-	-
Molegna	-	F	AAB	Abo/CI	mo	24	-	1	1
N'gretia	French round tip	F	AAB	Abo/CI	ng	24	-	1	1
Orishele	Orishele	FH	AAB	Aza/CI	or	34	1	1	1
Saci	Saci	F/FH	AAB	Aza/CI	sa	32	1	1	1
Cultivars used for validation									
FHIA 21	FHIA 21	Hyb	AAAB	Aza/CI	fh	33	-	1	-
PITA 3	PITA 3	Hyb	AAAB	Aza/CI	pi	34	-	1	-
Dominico Harton	Dominico harton	FH	AAB	Mpl/Fr	dh	38	2	3	-
Cavendish	Cavendish	D	AAA	Mpl/Fr	ca	30	1	-	-

[a] type: FH: False horn; F: French; RH: real Horn; F/FH: intermediate between French and False horn; Hyb: Hybrid; D: Dessert; Abo/CI: Aboisso/Côte d'Ivoire; Aza/CI: Azaguié/Côte d'Ivoire; Mpl/Fr: Montpelier/France; MG: mature green; HR : half ripe ; FR: fully ripe

1. Afoto

2. Allosso

3. Agnrin

4. N'grétia

5. Molègna

6. Kpatregnon

7. Kaki

8. Dechair

9. Saci

10. Big ebanga

11. Corne 1

12. Orishele

13. FHIA 21

14. Pita 3

15. Cavendish

16. Dominico harton

Figure 1 : Bunches, hands and fruits of the banana varieties used for the study (at the mature green stage)

2.1.3 Cooking conditions

a. Wash and hand-peel banana pulps
b. Immediately cook banana pulps in a large volume of boiling water in individual stainless-steel pans (6:1 tap water-to-banana ratio), in a dedicated room.
c. The cooking time was adapted to the stage of ripeness of the fruits, known traditional culinary habits, and some preliminary cooking trials. Cooking time was set to 10 min for fully ripe, 20 min for half-ripe and 30 min for mature green plantains.

NB: Define a rigorous schedule for the preparation of boiled plantain samples (Table II).

Table II : Example of planning of Boiled plantain sample preparation

Order of tasting	Products	Code of product	Start of cooking	Cooking duration (min)	End of cooking	Tasting at
1	**Ngr J4**	**405**	10h10	20	10h30	10h35
2	**Agn J4**	**12**	10h15	20	10h35	10H40
3	**De J0**	**107**	10h10	30	10h40	10H45
4	**Al J4**	**311**	10h25	20	10h45	10H50
5	**Be J0**	**55**	10h20	30	10h50	10H55
6	**PL J4**	**609**	10H35	20	10h55	11h00

Date: Tuesday 12-feb-2019 Session 1 time: morning

10h30 to 10h35: Discussion with the panelists relating to the definitions of the descriptors and their scale.

NB: Samples cooking time were precisely monitored and synchronized using lab timers to allow panelists to have samples on time (Figure 2).

Figure 2: Synchronised Boiling

3 TASTING SEQUENCE

3.1 General Information

3.1.1 Test Responsible Person/Group Animator

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3.1.2 Date/Time Phase of the test

The tests were carried out over the period from 12 to 19 February 2019 in morning and afternoon.

3.1.3 Sensory laboratory conditions

The relative humidity and temperature of the sensory laboratory were kept constant at 21+/-1°C and 24+/- 5% RH, complies with international standards Afnor.

3.2 Sample

3.2.1 Standardization of samples

At each cooking time, whole boiled plantains were removed from the water and dried superficially for less than 30 s using a soft absorbent tissue. After the apical and peduncle ends were removed, the cooked pulps were standardized by cutting into several 3 cm sections (Figure 3).

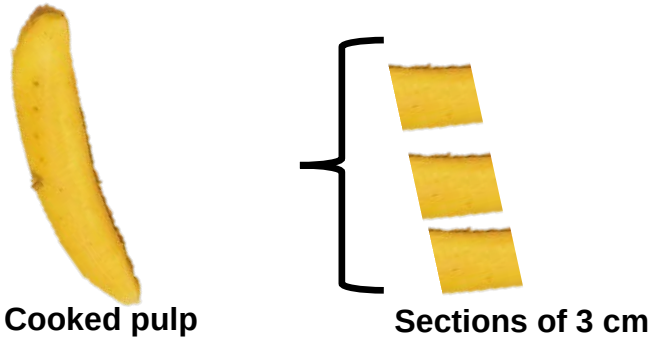

Figure 3: Samples standardization

3.2.2 Sample storage conditions

Each section of cooked pulps was placed in a porcelain dish prior to being served to the panellists at the desired time (Figure 4).

Figure 4: Monadic presentation of samples

3.2.3 Quantity of sample to be given to each panellist

Each section was served to the judges randomly.

3.2.4 Monitoring of Samples Temperature

A tasting protocol have been set up to ensure that all the panellists assessed the products at exactly the same target temperature. A K-type thermocouple was immediately inserted to the geometrical core of a reference sample of each boiled product. The temperature was monitored throughout the cooling process using an Almemo 2690-8A data logger (Ahlborn GmbH, Germany), placed in an individual box in the sensory laboratory which was in the immediate proximity of the cooking room (Figure 5).

Figure 5: Monitoring of temperature of reference sample

3.2.5 Repeated sample

A sample PL J4 (serving randomly), was tasted at all sessions.

3.2.6 Sample Codification

The samples were coded with an anonymous random 3-digit number (Table III).

Table III : List of samples tasted

Order of tasting	Variéty of banana	Ripening stage*	Cooking time	Products	Code of product	Replicate	Session	Tasting date (Time)
1	N'gretia	HR	20	Ngr J4	405	1	1	12-02-2019 (AM)
2	Agnrin	HR	20	Agn J4	12	1	1	12-02-2019 (AM)
3	Dechair	MG	30	De J0	107	1	1	12-02-2019 (AM)
4	Allosso	HR	20	Al J4	311	1	1	12-02-2019 (AM)
5	Big Ebanga	MG	30	Be J0	55	1	1	12-02-2019 (AM)
6	Dominico Harton	HR	20	PL J4	609	1	1	12-02-2019 (AM)
1	Molegna	HR	20	Mol J4	68	1	2	12-02-2019 (PM)
2	Dechair	HR	20	De J4	34	1	2	12-02-2019 (PM)
3	Fhia 21	HR	20	Fhi J4	500	1	2	12-02-2019 (PM)
4	Kpatregnon	MG	30	Kp J0	204	1	2	12-02-2019 (PM)
5	Dominico Harton	HR	20	PL J4	700	2	2	12-02-2019 (PM)
6	Afoto	HR	20	Afo J4	101	1	2	12-02-2019 (PM)
1	Pita 3	HR	20	PI J4	302	1	3	15-02-2019 (AM)
2	Kpatregnon	FR	20	KP J8	635	1	3	15-02-2019 (AM)
3	Corne 1	MG	30	COR J0	40	1	3	15-02-2019 (AM)
4	Orishele	MG	30	OR J0	501	1	3	15-02-2019 (AM)
5	Kaki	HR	20	KAK J4	90	1	3	15-02-2019 (AM)
6	Dominico Harton	HR	20	PL J4	125	3	3	15-02-2019 (AM)
1	N'gretia	FR	10	NGR J8	59	1	4	15-02-2019 (PM)
2	Molegna	FR	10	MOL J8	400	1	4	15-02-2019 (PM)
3	Agnrin	FR	10	AGN J8	20	1	4	15-02-2019 (PM)
4	Dechair	FR	10	DE J8	905	1	4	15-02-2019 (PM)
5	Afoto	FR	10	AF J8	100	1	4	15-02-2019 (PM)
6	Dominico Harton	HR	20	PL J4	70	4	4	15-02-2019 (PM)
1	Kpatregnon	HR	20	KP J4	600	1	5	19-02-2019 (AM)
2	Saci	MG	20	SA J0	230	1	5	19-02-2019 (AM)
3	Saci	HR	20	SA J 4	77	1	5	19-02-2019 (AM)
4	Orishele	HR	20	OR J4	780	1	5	19-02-2019 (AM)
5	Corne 1	HR	30	Cor J4	51	1	5	19-02-2019 (AM)
6	Dominico Harton	HR	20	PL J4	170	5	5	19-02-2019 (AM)
1	Cavendish	MG	30	CAV J0	90	1	6	19-02-2019 (PM)
2	Dominico Harton	MG	30	PL J0	22	1	6	19-02-2019 (PM)
3	Kaki	FR	10	KAK J8	308	1	6	19-02-2019 (PM)
4	Saci	FR	10	SA J8	107	1	6	19-02-2019 (PM)

Order of tasting	Variéty of banana	Ripening stage*	Cooking time	Products	Code of product	Replicate	Session	Tasting date (Time)
5	**Orishele**	FR	10	**OR J8**	**36**	**1**	**6**	19-02-2019 (PM)
6	**Corne 1**	FR	10	**COR J8**	**703**	**1**	**6**	19-02-2019 (PM)

**MG: mature green; HR: half ripe; FR: fully ripe*

3.3 Service

3.3.1 Number of samples tasted by session

Thirty-six (36) products were assessed in six sessions (*cf*. Tableau III).

3.3.2 Type of service

The samples were served monadically.

3.4 Tasting

3.4.1 Temperature of tasting

When the temperature of the reference sample dropped to 60 °C, a signal was given to the trained panellists to start tasting the samples, using an evaluation protocol and a scaling rate for each attribute (Figure 6). Before tasting a new product, panellists were required to rinse their mouth with mineral water.

NB: An average temperature of 50 °C was recorded when the panellists finished evaluating a product.

Figure 6: Tasting at 60 °C

3.5 Panel

3.5.1 Number of panellists who participate in this study

13 trained panellists (five women and eight men, aged between 21 and 60 years old) on the CIRAD Montpellier panel were participated at this study.

3.5.2 Training of panel

The panelists were trained, according to the method described in the RTBfoods deliverable entitled: Training a panel in sensory analysis and implementing descriptive Tests (2018).

Five different samples (different varieties and different stages of ripeness) were provided. Four sessions were needed to train panellists.
Panel performance (repeatability and agreement with panel) are provided in Table IV.

Table IV : Panel performance

Paneliste	Performance	Firmness	Chewiness	Mealiness	Stickiness	Sweetness	Moist
1	REPETABILITY	yes	yes	yes	yes	yes	yes
2	REPETABILITY	yes	yes	yes	yes	yes	yes
3	REPETABILITY	yes	yes	yes	yes	yes	yes
4	REPETABILITY	yes	yes	yes	yes	yes	yes
5	REPETABILITY	yes	yes	yes	yes	yes	yes
6	REPETABILITY	yes	yes	yes	yes	yes	yes
7	REPETABILITY	yes	yes	yes	yes	yes	yes
8	REPETABILITY	yes	yes	yes	yes	yes	yes
9	REPETABILITY	yes	yes	no	no	yes	yes
10	REPETABILITY	no	yes	yes	yes	yes	yes
11	REPETABILITY	yes	yes	yes	yes	yes	yes
12	REPETABILITY	yes	yes	yes	yes	yes	yes
13	REPETABILITY	yes	yes	yes	yes	yes	yes
1	AGREEMENT	yes	yes	yes	yes	yes	yes
2	AGREEMENT	yes	yes	yes	yes	yes	yes
3	AGREEMENT	yes	yes	yes	yes	yes	yes
4	AGREEMENT	yes	yes	yes	yes	yes	yes
5	AGREEMENT	yes	yes	yes	yes	yes	yes
6	AGREEMENT	yes	yes	yes	yes	yes	yes
7	AGREEMENT	yes	yes	yes	yes	yes	yes
8	AGREEMENT	yes	yes	yes	yes	yes	yes
9	AGREEMENT	yes	yes	yes	yes	yes	yes
10	AGREEMENT	yes	yes	yes	yes	yes	yes
11	AGREEMENT	no	yes	yes	yes	yes	yes
12	AGREEMENT	yes	no	yes	yes	yes	yes
13	AGREEMENT	yes	yes	yes	no	no	yes

3.6 Vocabulary

The panellists defined a descriptive vocabulary for boiled banana, which previously did not exist in the literature. Panellists were asked to list the sensory characteristics that they considered important to describe the boiled plantain. An additional session was needed to choose the pertinent attributes, agree on their definition and on the evaluation protocol.
To avoid panellists tiredness, six descriptors were selected: four for texture in the mouth (chewiness, firmness, stickiness and mealiness), one for taste (sweetness) and one for impression in the mouth (moistness).

3.7 Protocol of evaluation of boiled plantain sensory attributes

Excepted chewiness, the intensity of the attributes (firmness**,** mealiness, stickiness, sweetness, and moist feel) were evaluated on a discrete scale ranging from zero (0) for very weak to 10 for very strong (Table V).

3.8 Chewiness specific evaluation

Given the difference in the chewiness perception among the panellists, this attribute was the subject of a specific evaluation. Each of panellists was requested to count the number of chews prior to swallowing, and noted the corresponding value. As the number of chews varied greatly from one panellist to another, this number was computed in a non-dimensionalised form for each panellist, then converted to a value between 0 and 10 (0 being the lowest dimensionless value of all products and all panellists, and 10 the highest) (Table V).

NB: It is essential that Panellists chew a fixed quantity of sample (here a slice of 1 cm thick and 3 cm long piece).

Table V: Sensory attributes of boiled plantain assessed by trained panel

Attribute Family	Attribute	Definition	Evaluation protocol	Rating scale
Sensory Texture	**Firmness**	Force required to obtain deformation, penetration or rupture of the banana	Put in the mouth a piece of banana and Evaluate the force necessary to obtain the deformation of the product between the teeth during the first compression	0: Soft 10: Firm
	Chewiness	Energy or number of chews necessary to chew the banana to make it ready to be swallowed	Place the sample in the mouth, chew it at the rate of one chewing per second and assess the number of chews before swallowing.	number of chews
	Mealiness	Mechanical property linked to cohesion and the presence of fine particles in the product during chewing	Put a piece of banana in your mouth and assess the presence of mealiness particles during chewing	0: Low 10: Strong
	Stickiness	Force required to peel off the fraction of product adhering to the interior of the oral cavity	Press a piece of banana between the molars and appreciate the adhesion of the product	0: Low 10: Strong
Taste	**Sweetness**	Elemental flavor caused by dilute aqueous solutions of various substances such as sucrose or aspartame	Put a piece of banana in your mouth, chew it and swirl it around your tongue to detect the sweet flavor	0: Low 10: Strong
Mouth impression	**Moist**	Perception of the amount of water absorbed or released by the product	Once the flavors are detected, moisture is felt by turning the product in the mouth	0 : Dry 10: Moist

3.9 Pictures to illustrate the tasting sessions

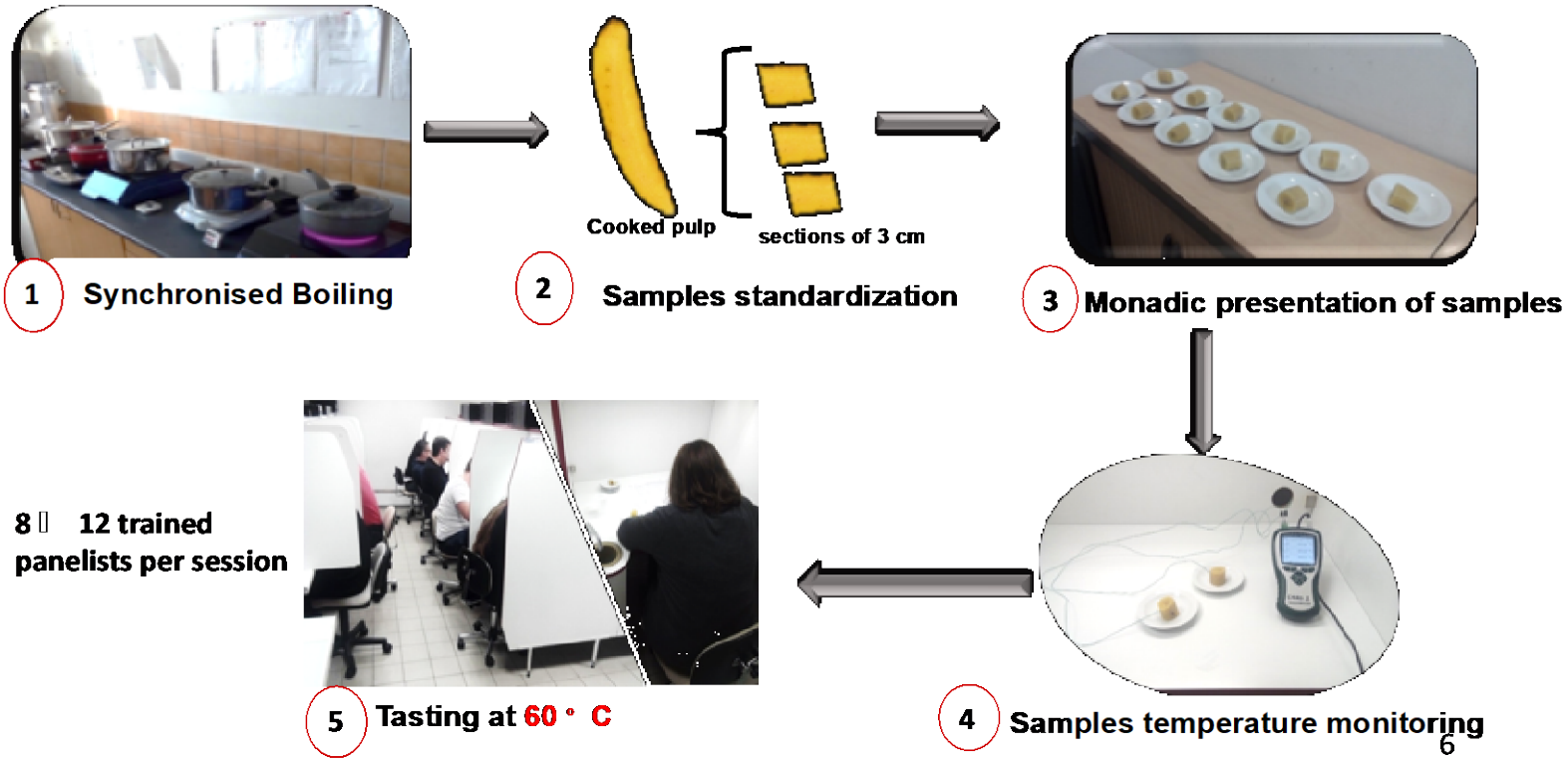

Figure 7: Principal steps of sensory evaluation of boiled plantain

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