Field Scientific Report

Participatory Processing Diagnosis of Boiled Yam in Benin

Understanding the Drivers of Trait Preferences and the Development of Multi-user RTB Product Profiles, WP1

Cotonou, Benin, June 2019

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Ethics: The activities, which led to the production of this document, 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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ABSTRACT

This study is part of the RTBfoods project WP1 outputs, essentially the step 3 of the developed methodology which deals with the quality traits of boiled yam, collected through a participatory processing diagnosis. Six local varieties with contrasting characteristics identified within the WP1 step 2 survey were processed into boiled yam by 6 qualified processors. Completes sets of quantitative data (raw material characteristics, yield, productivity, applied conditions for each unit operation) and qualitative data (raw material and end products evaluation) were collected in one small urban center, Bohicon - Benin. The varieties have been classified according their phenotypic characteristics according 3 groups having significant differences according their lengths and weights. Processors indicated that a variety could not be evaluated or selected only according its appearance. Significant differences were also identified on their dry matter content which ranged between 25.8 and 43.2 %. With regard to the peeling unit operation it is important that the peeled yam do not change colour. Regarding the cooking step, the control of the [Qwater/Qyam] ratio is important in the quality of the boiled yam, and in particular its textural friable homogeneity and the level of the stickiness. No significant varietal difference was observed as far as cooking time is concerned. The texture of the boiled yam pieces and the behaviour of the tubers during cooking appear to be related to the initial dry matter content. In our conditions, a minimum threshold for the dry matter content of the raw material seems to be around 30%. The processor's end products evaluation allowed to generate a complete set of good and bad descriptors on colour, textural, taste and flavor properties, with 16 good and 19 bad descriptors that have been useful for the step 4 of the WP1's methodology.

Keywords: Yam, boiled, flowsheet, yield, productivity, cooking, quality traits, evaluation.

1 CONTEXT AND GENERAL OBJECTIVES

This report is part of the RTBfoods project WP1 outputs, essentially the Step 3 which deals with the quality traits of boiled yam, collected through a participatory processing preparation/demonstration. The main output from Step 3 related to yam is to develop gendered product profile of **boiled yam**; The outline of this activity is to i) describe the different steps of the preparation, and the key processing unit operations in the quality of intermediate and boiled yam, ii) identify the quality characteristics of yam and boiled yam pieces in order to select some of them for the following consumer testing. This report aims to provide information on quality traits of raw yam, boiled yam processing steps and final boiled yam from six varieties.

2 METHODOLOGY

2.1 Study area

This study was carried out in a small urban center at Bohicon (Small town ; Zou Department ; 171 781 hab. INSAE, 2013) ; Figure 1) in the south of Benin.

Figure 1: Map of Benin - Bohicon

2.2 Raw material

Six (6) yam varieties with contrasting characteristics were obtained from the experimental field of Africayam project in Benin (experimental field located at Zogbodomey, district of Massi). These varieties were selected based on previous surveys (Step 2 of RTBfoods) and advices acquired from the Africayam project Beninese team. These varieties were Laboko, Kodjewe, Paina/Kokoro, Gnidou, Deba and Kpete (figure 2). They are all from the complex *D. rotundata-cayennensis*, except Kpete which is from *D. alata*. They were harvested after nine (9) months of plantation and stored during two (2) months at ambient temperature before use for this study.

Figure 2: Overview of the variability (phenotype) of the 6 varieties used (Photo A. Bouniol)

2.3 Boiled yam processing

The six yam varieties were coded with a random three-digit number. Six skilled workwomen processors were recruited to prepare boiled yam and then, to evaluate quality characteristics of each product along the process (at each step). Yam varieties were presented to each processor in random order. Each processor received at least one tuber of each variety, which weighed between 1.0 and 3.5 kg. The cooking was carried out (by usual practice of each processor) variety after variety consecutively in the random order previously obtained. During the preparation, the following data were collected by participatory approach:

- Raw Yam characteristics related to morphological aspects of tuber and boiled yam pieces (weight, long, circumference by measuring etc.)
- Unit operations of boiled yam preparation and some key technical data of each unit operation (mass balance, duration, temperature etc.)
- Quality characteristics of yam at each step of preparation into boiled yam and sensory evaluation of the final boiled yam from each variety.

3 RESULTS

3.1 Yam tuber characteristics

3.1.1 Variability in the weight of tuber and size length)

The average weight of yam tuber from varieties varied between 582.2 and 2759.3 g (range of 0.6 to 2.8 Kg). A tentative grouping based on the tuber weigh revealed that varieties can be clustered into 3 groups:

- Group 1: two varieties (*Kpete* and *Gnidou*) with a weight greater than 2000 g,
- Group 2: three varieties (*Laboko* / *Deba* / *Kodjewe*) with a weight between 1000 and 2000 g
- Group 3: one variety (*Kokoro païna*) of weight less than 1000 g.

As far as the length of tuber is concerned, mean values average ranged between 21.5 and 47.8 cm, but varieties can be clustered into 3 groups:

- Group 1: one variety (*Gnidou*) with a length greater than 40 cm ,
- Group 2: four varieties (*Laboko* / *Deba* / *Kodjewe/Kpete*) with a length between 30 and 40 cm
- Group 3: one variety (*Kokoro païna*) of length less than 30 cm.

Overall, three distinct groups were obtained when integrating length and weigh of yam tuber selected (figure 3)

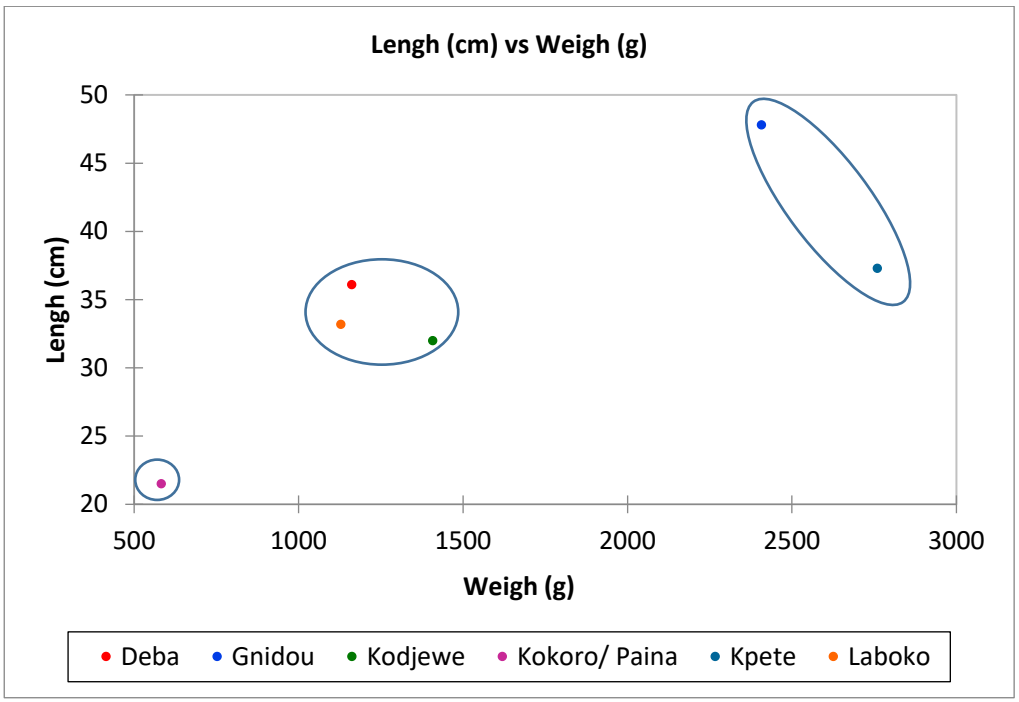

Figure 3: Position of yam varieties by Length versus Weigh of yam tuber

3.1.2 Shape

According to processors, three 3 main forms of tubers were observed between variety in study: they were cylindrical, conics and hands form (Table 1)

Table 1: Shape of the 6 chosen varieties

Yam varieties		Shape/form
Kpete		Big size ; forms of hands
Laboko		Medium and cylindrical sized
Païna/ Kokoro		Small sized tuber; forms of hands
Gnidou		Big size cylindrical
Deba		Small cylindrical size
Kodjewe		Medium and conic size

3.1.3 Quality characteristics collected on the raw material

In order to obtain a good quality of boiled yam, the right choice of yam tuber is achieved on the basis of many criteria.

The first step is an overall visual assessment of the tuber, even if they said that their assessment is never 100% reliable:

- the tuber should preferably be cylindrical or conical, have a slightly wide head and pointed tail.
- the skin of the tuber should be smooth, with the presence of thin lines on the peels.

- the presence of small rootlets and sometimes the roughness buttons were also considered.

Eg. Variety Laboko was recognized to have all these characteristics.

The second step consist of removing of a small piece of skin from the tuber using the nail to evaluate the quality of the flesh. Accordingly, they observed:

- The flesh color: it must be preferably white or slightly yellow. After the removing of a small piece of skin of tuber, the colour should not change. The varieties with pinkish or dark flesh or which flesh colour changed into pinkish or dark are not appreciated for boiling.
- Humidity and firmness of flesh: The flesh must have a given level of moisture and firmness, both evaluated by the touching/pressing. Varieties very wet and / or too firm were considered as poor quality to produce boiled yam.

Using these two first steps, processors are able to identify tubers as close as possible; however, they compared other varieties to the characteristics of the *Laboko* variety, which according to their experience and empirical knowledge is the reference yam variety.

Finally, the last criterion mentioned by the processors refers to their commercial strategy, and relates to the concept of quality / price. Indeed, some processors indicated that, depending on the time of year and market prices, they may choose the varieties that, *a priori,* do not meet preceding criteria of good quality of raw materials. This increases their income but also the possibility to propose a big portion of boiled yam piece at consumers.

3.1.4 Variance in dry matter content of raw yam

The dry matter content of yam tuber ranged between 25.8 and 43.2% (wet basis). Significant difference ($P < 0.05$) was observed between yam varieties tested, which were grouped into three (3) main classes:

- Group 1: two varieties (*Deba* and *Laboko*) with a dry matter content greater than 40% (40.3-43.2%, w.b)
- Group 2: three varieties (*Gnidou* / *Kpete* / *Kodjewe*) with dry matter content ranging between 30 and 40% (32.4-35.5% wb),
- Group 3: one variety (*Kokoro païna*) with dry matter content less than 30% (25.8%, w.b)

3.2 Boiled yam process description

The main unit operations of boiled yam productions were the washing, peeling/slicing and cooking. Although quite simple, the boiled yam process includes variants related to washing or to cooking (Figure 4): accordingly, washing can be achieved after peeling (usual practice) or before peeling. Regarding cooking, yam pieces can be completely immersed in water during cooking or directly exposed to hot steam. Processors prefer the water cooking mode to process small quantities and steam cooking for large quantities of yams. In our study, five processors cooked the yam with water and one according steamed process.

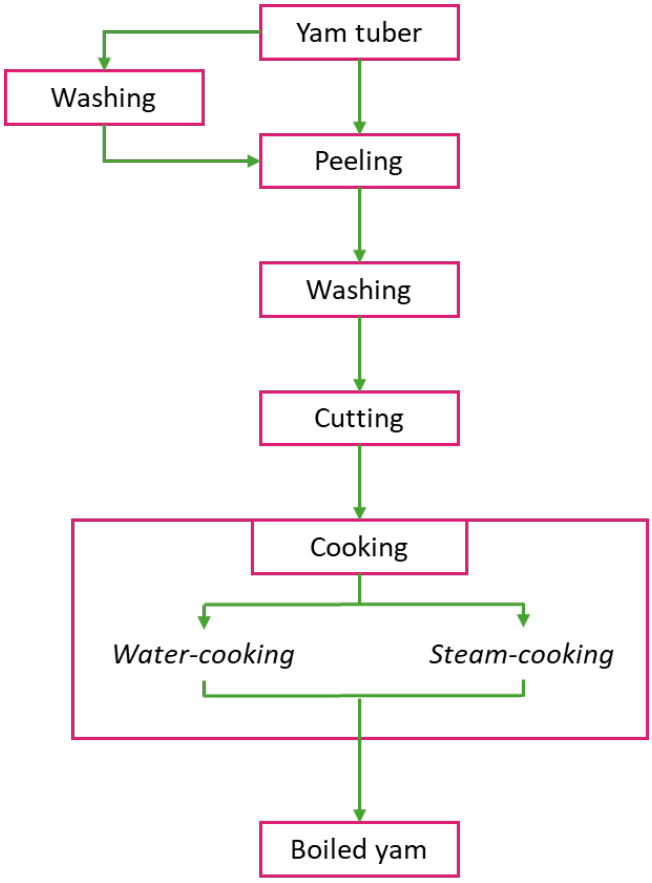

Figure 4: Flow diagram of boiled yam process

3.2.1 Peeling

Peeling unit operation was characterized by the processing yield (%, w.b) and productivity (kg/h/processor). The peeling yield varied from 66.5 to 79.4% (w.b), with no significant difference between the 6 varieties (Figure 5).

The productivity varied from 11.9 to 50.2 kg/h/operator, with a mean value of 36.6 kg/h/operator. Significant differences ($P < 0.05$) were found between yam varieties, with Païna giving the least productivity of 11.9 Kg/h/processor (Figure 5).

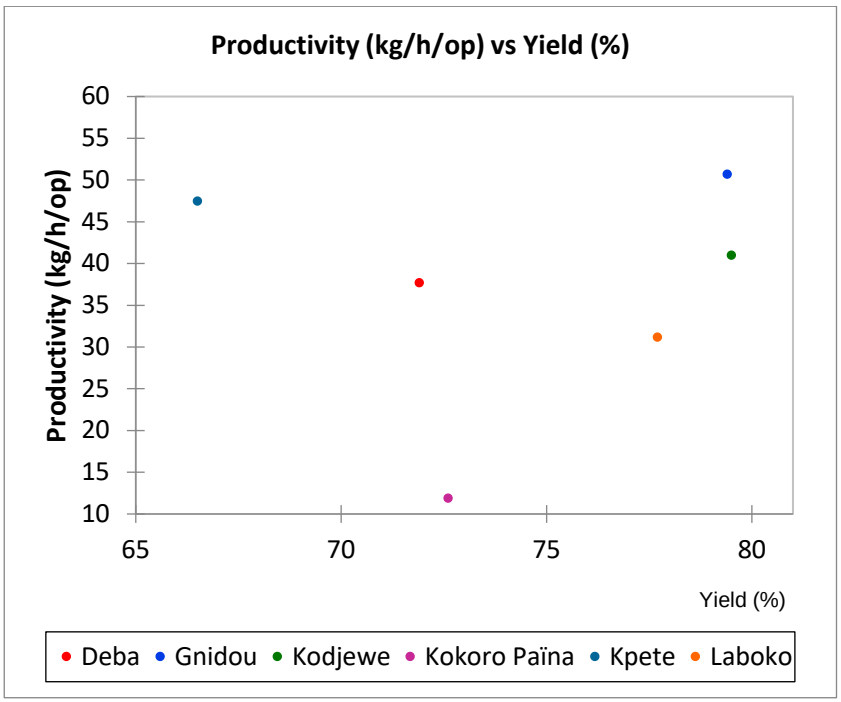

Figure 5: Peeling yield versus productivity per yam variety (% w.b)

3.2.2 Washing

This unit operation is very fast probably due to the low quantity processed (one tuber); so, no data were collected. Nevertheless, it should be noted that the washing step of peeled yam is very carefully carried out to avoid the presence of organic and/or inorganic matters. In the case of the processing of a large quantity, processors store the peeled yam in the water until the end of the peeling operation in order to avoid any blackening phenomenon due to oxidation.

3.2.3 Slicing/Cutting

Cutting operation was characterised by the average weigh of the yam pieces (g) and the productivity (kg/h/operator). The average weigh of a boiled yam pieces varied between 44.9 to 67.9 g (Table 3).

The quality criteria required at this step are (Table 4):

- Keeping of white or yellow colour of flesh during peeling and slicing
- No sticky flesh and low humidity
- The flesh is neither too hard nor too soft. For the processors, it is necessary to produce a minimum effort to cut the yam.

In our study, two (2) varieties (*Kpete* and *Gnidou*) have a rosy complexion to red from the peeling and they are not easy to handle because very sticky (probably due to a lot of pectins; figure 6).

In addition, an intrinsic heterogeneity of colour of different parts of tuber after peeling and cutting were highlighted in figure 7. eg, the proximal part of the tuber becomes pinkish with the intensity depending of the varieties. This part of the tuber is generally scored hard by the consumers.

Figure 6: Evolution of colour of Gnidou during peeling (Photo A. Bouniol)

Figure 7: Colour of head yam pieces (top of the photo) and the rest of the tuber (bottom of the photo) – (Photo A. Bouniol)

3.2.4 Cooking

In the water-cooking system, processor places peeled yam pieces into a pot while cooking, and a little salt (Figure 8). The pot is covered with a lid. For the steaming system, processor places the cooking water and a support metal at the bottom of a pot (figure 9). On the support, is deposited a polypropylene bag on which the pieces of peeled yam are placed with a little salt. The pot is covered with a lid.

The following parameters were measured during cooking: ratio water/yam, [Quantity of water introduced in the system (Qw) / Quantity of peeled yam pieces (Qy)], duration, temperature monitoring and the yield. This ratio [Qw/Qy] varied from 0.41 to 0.59 for the water-cooking pattern, and from 0.77 to 2.33 for the steam-cooking (Figure 10).

During the cooking, processors added 4 to 8 g of salt depending on the quantity of yam to cook.

Figure 8: Water-cooking system

Figure 9: Steam-cooking system

Ratio [Quantity of water introduces in the system (Qw) / Quantity of peeled yam pieces (Qy)]

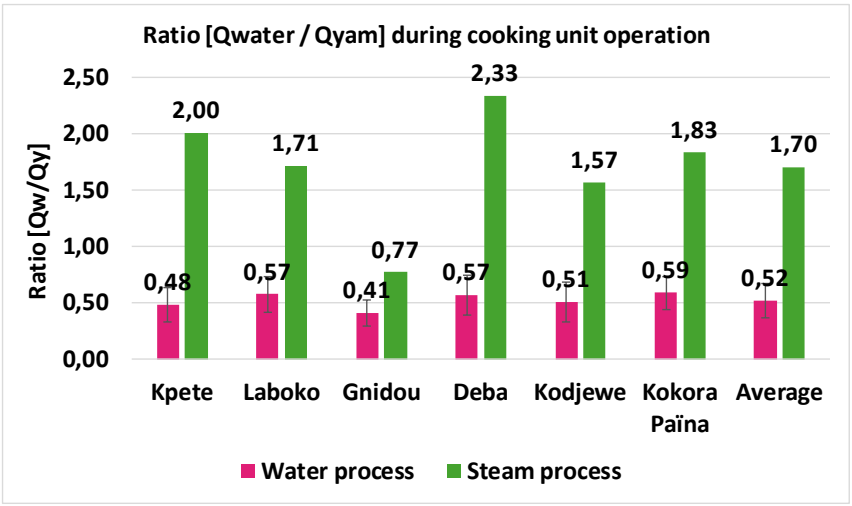

Figure 10: Ratio [Q.water/Q.yam] during cooking unit operation

In the steam-cooking mode, the processor provides a quantity of water in excess. In this case, the yam pieces do not contain too much water and are not too sticky. Conversely, to avoid this pitfall during cooking by immersion in water, the processors add the amount of water needed to cook the yam pieces, avoiding an excess of water, otherwise the yam pieces will absorb too much water and may become sticky, which is a criterion for consumers to reject the end-product.

According to processors, the cooking operation by immersion in water is the determining step to obtain a high quality boiled yam. This step requires the highest level of expertise and know-how. In the case of steam cooking, this is not critical step. This cooking mode significantly reduces the risk to obtain product with too much water, sticky or pasty boiled yam

Cooking time

The cooking time is defined from the beginning of the fire until the end of cooking.

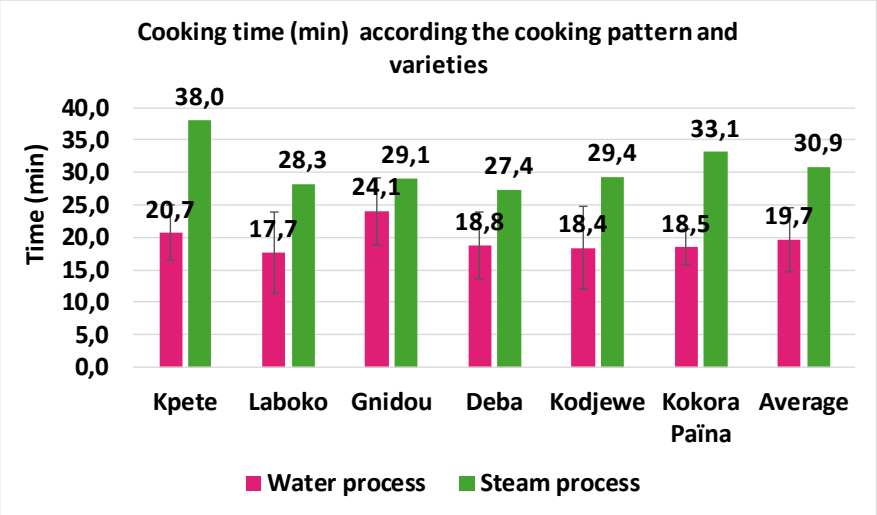

Figure 11: Cooking time (min) according the cooking pattern and varieties

The cooking duration varies from 17.7 to 24.1 min for the water-cooking pattern, and from 27.4 to 38.0 min for the steam-cooking (Figure 11). The processors revealed that a long cooking time by immersion in water leads to overcooked yam pieces, with too much water; and such product sticks to fingers. In addition, the disintegration of structure of cell wall is more rapid in contact with water than steam water.

Evaluation of the end of cooking (cooking time)

The processors used different techniques to identify the end of cooking:

- The use of fork to monitor sporadically the softness of yam pieces. The easy to reach the heart of yam piece using a fork is referred to the end of cooking.
- The viscosity of the residual cooking water is also an indicator of the degree of cooking. At the end of cooking, the residual water is supposed to be slightly viscous.
- The stickiness of yam pieces is evaluated by touching it with the back of a fork.
- Boiled yam pieces must maintain their white or yellowish color or become creamy, pearly giving the vitreous appearance. Processors considered these characteristics as a indicator of friability

Dry matter of cooked yam

The dry matter content varied between 23.7% and 38.1% (Figure 12), with significant differences ($P < 0.05$) between the varieties which were regrouped into 3 main groups:

- Group 1: one variety (*Deba*) with a dry matter content more than 35 %
- Group 2: four varieties (*Gnidou / Kokoro Païna / Kodjewe / Laboko*) with dry matter content between 30 and 35 %,
- Group 3: one variety (Kpete) with dry matter content less than 30 %

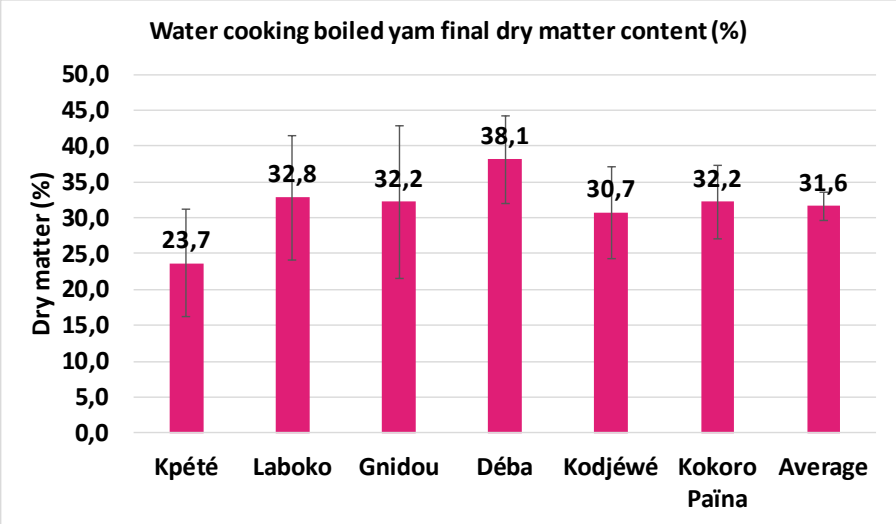

Figure 12: Dry matte of boiled yam obtained during water cooking (%, wb)

The yield (% d.b) of the water-cooking unit operation varied between 81.9 to 99.9 % d.b, with an average for all varieties of 93.0 %. As far as cooking step is concerned, significant differences ($P < 0.05$) between the varieties were observed, leading to 3 main groups:

- Group 1: three varieties (*Kodjewe, Gnidou, Kokoro Païna*) with a yield close to 100 % d.b.
- Group 2: one variety (*Deba*) with a yield of 92.7 % d.b,
- Group 3: two varieties (*Laboko* and *Kpete*) with yields respectively 85.6 and 81.9 % d.b.

It can thus be assumed that varieties with a significant loss of dry matter during this cooking step (*Laboko, Kpete* and *Deba*) have matrices sensitive to heat treatment, inducing a loss of material during cooking, which does not seem to be the case for the other varieties, which yield is close to 100% (*Gnidou, Kodjewe, Kokoro Païna*). We can assume that this loss of dry matter will have an impact on the textural properties of the end-product.

3.3. Processors' sensory testing of boiled yam

The boiled yam pieces produced from the six varieties were evaluated by the processors to provide attributes that describe the end-product, and then their preference (Figure 13 & 14). Thirty-four (34) descriptors were collected related to colour, texture, taste and aroma (Table 2). These descriptors were grouped in high and poor quality of each attributes. These descriptors were collected during the earlier survey, proving the confidence of results from both sources.

Figure 13: Overview of boiled yam pieces (Photo A. Bouniol)

Figure 14: Appreciation of the boiled yam pieces by the processor (Photo A. Bouniol)

Table 2: End-products descriptors collected after processing and evaluating by each processor

Colour		Textural		Taste		Flavour	
High quality	Poor quality	High quality	Poor quality	High quality	Poor quality	High quality	Poor quality
White Light white Shiny Yellow Yellowish Attractive	Red Pink Dark Dark white Slightly olive Ugly Not attractive	Soft Friable Slightly sticky in hand Firm Easy to break Hard Easy to chew Tender	Hard Sticky Gluey Unbreakable Lumpy Fibrous Do not stick to the hand Mealy	Sweet	Unsweet Uncooked Bitter	Yam odour	Unpleasant smell of root

Regarding preference of boiled yam, five out of six processors chose *Laboko* as the best variety for boiled yam while least preferred variety is *Kpete* as revealed by all processors. The appearance of tuber (presence or absence of rootlets and/or rays etc.), the easiness of peeling, the stability/constancy of colour during peeling and cooking, the stickiness of yam in the hand during peeling and slicing, the viscosity of cooking water were the characteristics considered to select the best preferred varieties or to reject the least preferred ones.

3.4. Global process yield

The processing yield of the boiled yam varied from 60.2 to 87.7 % w.b, eg from 57.8 to 80.2 % d.b (Figure 15). The variety *kpete* had the worst performance over the entire process, particularly the lowest peeling yield (66.5 % w.b). In addition, it is the variety which cooking yield is the lowest (81.9 % d.b).

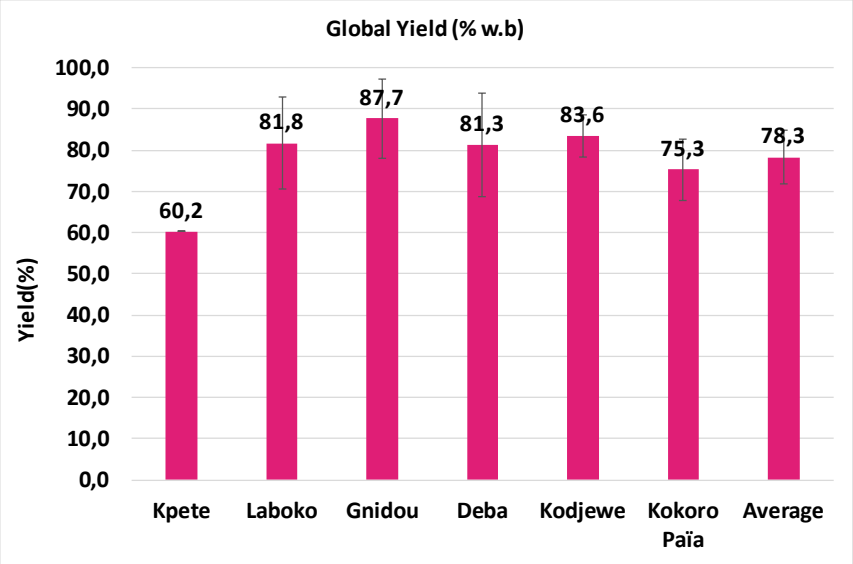

Figure 15: Global processing yield (% w.b)

4 SYNTHESIS AND CONCLUSION

The findings from the participatory processing with well skilled processors were summarized in table 3. Concerning **the yam tuber choice,** the external morphologic observation of the phenotype of tubers together with flesh characteristics can help to predict the final quality of boiled yam.

With regard to the **peeling unit operation**, two main observations should be noted:

- In terms of the final quality of the product, it is important that the peeled yam do not change colour.
- In terms of productivity, it is important to identify tubers with a shape facilitating their peeling, ie a cylindrical to conical shape.

Regarding slicing operation, two parameters were considered:

- The stickiness of yam in the hand during slicing, this is an indicator of high starch content. Some processors revealed that a tuber with high starch content will be higher in quality of boiled yam.

Regarding the **cooking unit operation**, the data collected revealed that:

- For the water cooking mode, the control of the [Qw/Qy] ratio is important in the quality of the boiled yam, and in particular its textural homogeneity and the level of the sticky.
- The definition of cooking time is done in different ways. It's sometimes evaluated by the ability of fork to pick the boiled yam or by the viscosity of cooking water.
- The texture of the boiled yam pieces and the behaviour of the tubers during cooking appear to be related to the initial dry matter content. In our conditions and in particular for tubers with a post-harvest age of 2 months, a minimum threshold for the dry matter content of the raw material seems to be around 30%. In fact, the two varieties that are most likely to lose dry matter during cooking unit operation are the *laboko* and *kpete*. It is noted that the *laboko* variety despite a significant loss of dry matter (loss of 14 %) gives end-product with a dry

matter greater than 30% and a perfectly friable texture while the *kpete* variety has significant losses during cooking (loss of 18 %), but the texture of the end-product remains hard and induces a frank rejection of the end-product.

It therefore seems decisive to characterize the biochemical composition of the tubers (starch content, quality and type of cell walls and other fibers etc.) in order to try to link it to the observations made and ultimately to understand which biochemical elements responsible for the textural quality of the products.

With regard to the Step 3 methodology implemented, it is important to remember that the initial choice of the variety set is decisive for obtaining good results. The choice made here proved to be relevant by providing excellent variability in tuber characteristics and behaviors. We can underline here the interest to work in close collaboration with breeders involved in breeding programs (Africayam for yam in our case).

Table 3: Synthesis of main quantitative data collected

	Raw material characteristics			**Processing quantitative data**								
				Peeling unit operation		**Cutting unit operation**		**Cooking unit operation***			**End-products**	**Global process yield**
Varieties	Weight (g)	Length (cm)	Dry matter (%)	Yield (%)	Productivity (kg/h/op)	Piece size (w)	Productivity (kg/h/op)	Ratio [Qw/Qy]	Cooking time (min)	Yield (%)	Dry matter (%)	Yield (w.b)
Deba	1161.5^{b}	36.1^{c}	43.17^{a}	71.9^{a}	37.7^{a}	56.2^{b}	45.4^{b}	0.57^{a}	18.8^{a}	92.7^{b}	38.1^{a}	81.3^{a}
Laboko	1128.3^{b}	33.2^{c}	40.23^{a}	77.7^{a}	31.2^{a}	57.2^{b}	54.1^{b}	0.57^{a}	17.7^{a}	85.6^{c}	32.8^{b}	81.8^{a}
Gnidou	2407.2^{a}	47.8^{a}	35.45^{b}	79.4^{a}	50.7^{a}	67.9^{a}	74.7^{a}	0.41^{a}	24.1^{a}	99.2^{a}	32.2^{b}	87.7^{a}
Kpete	2759.3^{a}	37.3^{b}	25.78^{b}	66.5^{a}	47.5^{a}	52.3^{b}	42.5^{c}	0.48^{a}	20.7^{a}	81.9^{c}	23.7^{c}	60.2^{b}
Kodjewe	1407.3^{b}	32.0^{c}	32.36^{b}	79.5^{a}	41.0^{a}	53.6^{b}	60.8^{b}	0.51^{a}	18.4^{a}	99.9^{a}	30.7^{b}	83.6^{a}
Kokoro Païna	582.2^{c}	21.5^{d}	33.63^{c}	72.6^{a}	11.9^{b}	44.9^{c}	67.4^{c}	0.59^{a}	19.7^{a}	98.7^{a}	32.2^{b}	75.3^{a}
Mean Value	*1574.3*	*34.7*	*35.10*	*74.6*	*36.6*	*55.3*	*57.5*	*0.52*	*19.7*	*93.0*	*31.6*	*78.3*

^{a,b,c,d} *indicates membership in significantly different value groups with a P value < 0.05*

**Water cooking data*

Table 4: Synthesis of main qualitative data collected

Variety	Raw yam				Boiled yam pieces					
	Agronomical characteristics	Processing characteristics at each step			Sensory characteristics					
		Peeling	Shaping/ washing	Cooking	When you look at	Texture when you touch	When you smell	Taste (In mouth)	Texture when you chew	After-taste
Laboko	The tuber has a large and convex head. Sometimes, it's flat. The tuber has lines on the peels. When peeling with the nail, the color of the flesh does not change for days. The skin is smooth and free from hairless	The skin is thin. The flesh does not change colour during peeling. The tuber is very easy to peel and the flesh is attractive. The losses during peeling are very low. The flesh does not stick to the hand	The flesh does not stick to the hand. The slices are homogeneous in shape. The cutting is easy and the tuber breaks easily. It's low in water content. .	The cooked yam piece has a white and attractive colour which is stable during cooking (good quality). It is soft and the fork sinks easily into it. It's very friable and the fork can't collect without to break it	Attractive; white or yellowish	It's soft and crumbly and breaks easily. Very sticky/ slightly sticky/don't sticky by hand		Very sweet / slightly sweet / sweet	Easy to chew; Slightly sticky/ doesn't stick in the mouth (good quality); Friable in the mouth.	

Variety	Raw Yam				Boiled yam pieces					
	Agronomical characteristics	Processing characteristics at each step			Sensory characteristics					
		Peeling	Shaping/ washing	Cooking	When you look at	Texture when you touch	When you smell	Taste (In mouth)	Texture when you chew	After-taste
Gnidou	The tuber is cylindrical (good quality) and skin is smooth (good quality). The flesh is pretty and attractive	The water content of tuber is low (high boiled yam quality). The flesh is red and/or purple during peeling (poor quality). The skin is fine and the peeling is quick and easy.	The flesh is not sticky / sticky. The flesh is red and purple on the surface. The cutting is easy and yam pieces have a slightly rough interior surface.	The cooked yam piece is slightly dark. The red and purple colour of flesh observed at peeling turn dark. The cooked yam piece is not friable, too hard and it's difficult to get the fork down (poor quality) / he has inflated and fork sinks easily (good quality). It's not very sweet /sweet in the mouth (poor quality).	White and attractive colour, slightly dark/dark and no attractive	It's friable/easy to break (good quality); it's no friable and slightly/toot hard (poor quality); No sticky to hand (poor quality). It's floury (poor quality). It's soft.	Unpleasant odour	Slightly bitter, insipid, sweet, pleasant taste	No sticky in mouth	Bitter aftertase

Variety	Raw Yam				Boiled yam pieces					
	Agronomical characteristics	Processing characteristics at each step			Sensory characteristics					
		Peeling	Shaping/ washing	Cooking	When you look at	Texture when you touch	When you smell	Taste (In mouth)	Texture when you chew	After-taste
Kodjèwé	The tuber has a pointed tip. The peel was clearly visible and parallel lines. The skin is not smooth.	The skin is thick; It's low in water and does not change colour (good quality). The flesh doesn't stick to your hand. Peeling is easy / difficult	The flesh doesn't change color. It's hard to cut. The slice pieces have a rough inner surface (indicator of friability). It's not sticky to the hand. Washing water is not viscous.	The cooked slice keeps its white colour during cooking. It has an attractive colour and good smell. The fork sinks easily into it and it's crumbly	Attractive white or yellow colour; Blackish but slighlty attractive	It's very crumbly; too hard and difficult to break with hand. Sticky to the hand		It's very sweet/ Tasteless/ Good to eat	Easy to chew and sticky in mouth	

Variety	Raw Yam				Boiled yam pieces					
	Agronomical characteristics	Processing characteristics at each step			Sensory characteristics					
		Peeling	Shaping/ washing	Cooking	When you look at	Texture when you touch	When you smell	Taste (In mouth)	Texture when you chew	After-taste
Païna (Kokoro)	Flat tuber	The tuber has a flat shape with fingers, which increases peeling difficulty and time . The skin sticks to the flesh, the quality of the boiled yam is not affected but the peeling yield is very low. The flesh doesn't change colour. The tuber has low water content (good quality). The skin is fine (good quality)/thick.	The flesh is not sticky. It's tender, difficult to slice (requires a lot of strength). Slices pieces were smooth inside.	It is easy to take with the fork and does not change colour. Cooking water is not very viscous. The fork sinks easily. It's crumbly and soft to warm but hard after cooling. It has a good yam smell.	No attractive blackish colour; Attractive yellowish and white colour	Presence of fibers, soft; neither soft nor hard, hard and difficult to cut, crumbly, no sticky,		Sweet, Good to eat, slightly tasteless, slightly bitter	It's crumby in mouth but no sticky in tooth. It's hard in mouth.	

Variety	Raw Yam				Boiled yam pieces					
	Agronomical characteristics	Processing characteristics at each step			Sensory characteristics					
		Peeling	Shaping/ washing	Cooking	When you look at	Texture when you touch	When you smell	Taste (In mouth)	Texture when you chew	After-taste
Déba (Kokoro)	The tuber has rays and rootled, the skin is thorny. The flesh doesn't change colour during peeling. The head and tail are pointed.	The flesh keeps the white colour during peeling. The head has red colour but the other parts of tubers have white colour. The tuber is easy to peel for some processors and difficult for others. The skin is thick and the tuber is low in water (the flesh does not stick to the fingers). The flesh has small yellow spots.	The peeled tuber has small yellow spots on the surface and inside and red spots at the head. It is more difficult to cut (good quality) because the water content is very low. It doesn't stick to the knife.	The yam pieces keep the colour during cooking. It's crumbly and slightly soft/very soft. It sticks to the back of the fork, easily breaks in half with fork	Attractive white and yellowish colour. No attractive blackish colour. Presence of starch (a starch gel cover the boiled yam pieces after cooking, good quality).	Slightly crumbly, slightly soft and slightly hard. Sticky/no sticky to the hand	Pleasant odour of boiled yam	Very sweet, slightly sweet, good to eat	Sticky to the mouth, tender	

Variety	Raw Yam				Boiled yam pieces					
	Agronomical characteristics	Processing characteristics at each step			Sensory characteristics					
		Peeling	Shaping/ washing	Cooking	When you look at	Texture when you touch	When you smell	Taste (In mouth)	Texture when you chew	After-taste
Kpètè	The flesh has red colour as soon as you peel with the nail. The tuber has large branches and no characteristics of the head. The tuber has no attractive; it has longer and big rootlets on her skin and has no rays.	The flesh is red and sticky during peeling. Peeling is difficult because requires a physical strength. The peeling is achieved several times for the success of this operation. The tuber has a lot of water and slips between the hands because it's sticky	The flesh is sticky and sticks to the knife and hand. The peeled yam slips into your hands because it's very sticky. The red color was observed on the surface and inside the slice. The tuber is easy to cut for some processors and difficult for others	It's red during peeling (poor quality). It seems to be not well cooked despite the cooking time. The cooking water is fluid. When I push my finger, I find that it's cooked but it will not be good to eat. It's very hard.	Red colour and no attractive. Ugly boiled yam pieces	Irrespective of cooking time, it's hard as an uncooked product. It's sticky and cooking water is viscous probably because the starch content. It difficult to break with hand and it's sticky inside. Presence of lumps and fibers were observed on some boiled yam pieces		Not sweet, tasteless, slightly dislike	Not good to eat and presence of lumps	

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