Field Scientific Report

Participatory Processing Diagnosis of Fried Sweetpotato in Nigeria & Ghana

Understanding the Drivers of Trait Preferences and the Development of Multi-user RTB Product Profiles, WP1, Step 3

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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

A participatory processing diagnosis on fried sweetpotato was conducted with expert fryers to better understand desirable and non-desirable quality characteristics from their perspective. The study encompassed 20 expert fryers across 8 communities in Nigeria (Kano and Kwara States) and Ghana (Bawku, Upper East Region). In both countries, the desirable characteristics of raw sweetpotato for use in the frying operation included; smooth skin, regular shape, big root size, no holes, no off-odours and firmness. The main unit operations involved in preparation were five namely; peeling, slicing, washing, salting and deep frying. Deep frying was the most important unit operation determining the quality of fried sweetpotato product (involved pre-heating vegetable oil 120-185°C). During processing important attributes included; hard when slicing, non-sticky and non-slippery in the hands, uniform colour of slices, non or slight surface moisture and no off-odours. The fried sweetpotato desirable traits were; colour (uniform light brown or yellow/golden, orange with a brown tint), dry/filling/satisfying, hard/strong -at first bite, crispy, not soggy, not oily, and slight-moderately sugary. Preference of the varieties from most to least preferred by processors in Ghana was; Obare, Purupuru, Kuffour and Amuskwera with weighted scores of 32, 21, 16 and 11 respectively. In Nigeria, processors in Kwara State liked Alausa (32) most followed by Pakurumo (21), Tomude (18), Aragbe (12), Mother's Delight (9) and Elege (6) while for those in Kano state it was; Dan Izala (36), Dan China (24), Dan Bakalori (18), Dan Madagali (14), Dan Barmawa (8), Dan Silver (6) and Mother's Delight (6).

Key words: Frying, sweetpotato, expert fryers, participatory, demonstration, characteristics

1 STUDY CONTEXT AND GENERAL OBJECTIVES

This report summarizes findings from participatory processing demonstrations and individual interviews with expert fryers of sweetpotato in Ghana and Nigeria. This is part of the product profiling study for fried sweetpotato in Ghana and Nigeria, which seeks to understand processors' demand for quality characteristics of the crop, and to provide breeders with appropriate information for breeding for high quality and acceptable sweetpotato varieties to enhance sweetpotato consumption in the region. In Nigeria the study was conducted in Kwara and Kano States. While in Ghana the study was conducted in Bawku Municipality of Ghana. The report identifies the important attributes/ characteristics of quality raw materials for fried sweetpotato and key processing unit operations important in the quality characteristics and sensory properties of the final product.

2 METHODOLOGY

2.1 Study area

The study was conducted in September 2019 in Kano and Kwara States in Nigeria, and Bawku in the Upper East Region of Ghana, all known major sweetpotato producing areas. Champion fryers from 3 urban centers namely Offa in Kwara State, Kano in Kano State and Bawku central in the Northern region of Ghana and 5 peri-urban areas namely Ijagbo and Agbamu in Kwara State. Bangwai and Garko in Kano and Manga in Bawku were also interviewed. Data was collected from 20 expert fryers across 8 communities in Nigeria and Ghana.

2.2 Raw material choice

The varieties used in the demonstration tests were selected based on inferences from characteristics and indicators for quality fried sweetpotato as obtained from focus group and individual interviews in Activity 3 for each community. The selection was based on three categories; most preferred, moderately preferred and least preferred for fried sweetpotato variety in the locality. An orange-flesh variety that is not a common variety, and not yet adopted by the locals, was intentionally added to increase variability. All varieties were at approximately 3 - 4 months' maturity at the time of harvest. The varieties selected to be used for the demonstrations in the respective locations are shown in Table 1 and Figure 1.

Table 1: Sweetpotato varieties used for participatory processing demonstrations and individual interviews with expert fryers of sweetpotato in Nigeria and Ghana

Country/State	Community	FGD inference criteria for varieties			
		most preferred	Moderately preferred	Least preferred	Orange fleshed sweetpotato variety
Nigeria/Kwara	Ijagbo	Pakurumo	Tomude	Elege	Mother's Delight
Nigeria/Kwara	Agbamu	Alausa	Tomude	Aregbe	Mother's Delight
Nigeria/Kwara	Offa	Pakurumo	Pakurumo	Agric. Elege	Mother's Delight
Nigeria/Kano	Bagwai	Dan Izala	Dan Madagali	Dan Silver	Mother's Delight
Nigeria/Kano	Garko	Dan Bakalori	Dan. China	Dan Baramawa	Mother's Delight
Nigeria/Kano	Kano	Dan China	Dan Izala	Dan Baramawa	Mother's Delight
Ghana/Upper East	Bawku	Obare	Purupuru	Amuskwera	Kuffour
Ghana/Upper East	Manga	Obare	Purupuru	Amuskwera	Kuffour

(a) **(b)** **(c)**

Figure 1: Some sweetpotato varieties from Kwara state (Nigeria); (a) Agric Elege, (b) Agric Pakurumo and Upper East state (Ghana); (c) Amuskwera

2.3 Product profile processing

Expert fryer demonstrations were conducted in the early hours of the day prior to consumer taste tests in rural and urban market segments. Each was given the same consumable materials; i.e cooking oil, salt, sweetpotato roots and charcoal (firewood) while they provided non consumables like frying equipment for the demonstration and frying. Four sweet potato varieties were used in each location. For proper time management each champion fryer was given 2 varieties to fry and interchange at second round trial. The processing steps (unit operations) were thoroughly followed and monitored (frying temperature, doneness specification, energy (fire) regulation) by asking expert fryer questions relevant for information needed in the template provided. Root samples from each location were shipped to the Post Harvest laboratory at the CIP's Sweetpotato Support Platform for West Africa in Kumasi Ghana to determine the flesh colour and dry matter content and descriptive sensory analysis.

3 RESULTS

3.1 Raw material characteristics

3.1.1 Flesh colour and dry matter content

The flesh colour and dry matter content of the sweetpotao varieties are shown in Table 2. In Nigeria, dry matter was in the range 18% (Mother's Delight) to 40.7% (Alausa) while in Ghana it was 27.1% (Amuskwera) to 26.4% (Obare).

Table 2 Flesh colour and dry matter content for the varieties used for champion fryer interviews

Country	Variety	Location	Flesh colour	Dry Matter content (%)
Nigeria	Dan Silver	Kano State	Light cream	34.3
	Dan Madagali	Kano State	Light yellow	24.6
	Dan Baramawa	Kano State	Deep cream	30.8
	Dan Bakalori	Kano State	Light cream	30.8
	Dan China	Kano State	Light yellow	33.7
	Dan Izala	Kano State	Deep cream	36.9
	Aregbe	Kwara State	Light yellow	37.1
	Tomude	Kwara State	Light yellow	37.8
	Elegbe	Kwara State	Light yellow	36.9
	Alausa	Kwara State	Light yellow	40.7
	Pakuromo	Kwara State	Light yellow	31.4
	Mother's Delight	Kwara State	Deep orange	18.0
Ghana	Amusikwera	Upper East region	Deep cream	27.1

Country	Variety	Location	Flesh colour	Dry Matter content (%)
	Purupuru	Upper East region	Deep cream	29.6
	Kuffour	Upper East region	Deep orange	28.4
	Obare	Upper East region	Light cream	36.4

3.1.2 Qualitative information collected on the raw material

The desirable chaarcteristics of raw sweetpotato to be used to process fried sweetpotato are summarised in Table 3. The key characteristics included; smooth skin, regular shape, big root size, no holes, no off-odors and firmness.

Table 3 :Desirable characteristics of the raw sweetpotato for a fried sweetpotato product

Characteristic	Why it is important
Smooth skin	Makes it easy to peel ie., in the absence of *lumps* (described as 'lumpy nature' by fryers) peeling takes less time and you get more slices.
Regular shape	Makes it easy to peel and slice the root for frying
Big root size	Important to fryers because it was easier to peel and slice (with lesser risk of injuring oneself) and will yield more slices
No holes	Makes the root easier to peel and will yield more slices- less to discard. Also, an indication of no pest infestation, and by inference, healthy roots.
No off odors	An indication of healthy roots/ no pest infestation
Firm	The roots are usually hard to slice, an indication of low moisture content which is associated with less frying time, and subsequently less oil consumption.
Earliness	Indicates availability of during the year
Stores well	Reducing losses after the roots have been harvested, which ensures good market and availability during off seasons.
High yield	Indicates obtaining more slices from high yielding varieties, which ensures more income

3.2 Product profile process description

3.2.1 Unit operations of fried sweetpotato processing

There were no peculiar differences in the processing steps for fried sweetpotato in the areas studied. Six (6) main units were identified from all locations and two (2); washing and salting, are done concurrently resulting in five (5) key processes. A flow sheet summarizing the general product processing steps in the study areas is presented in Figure 2.

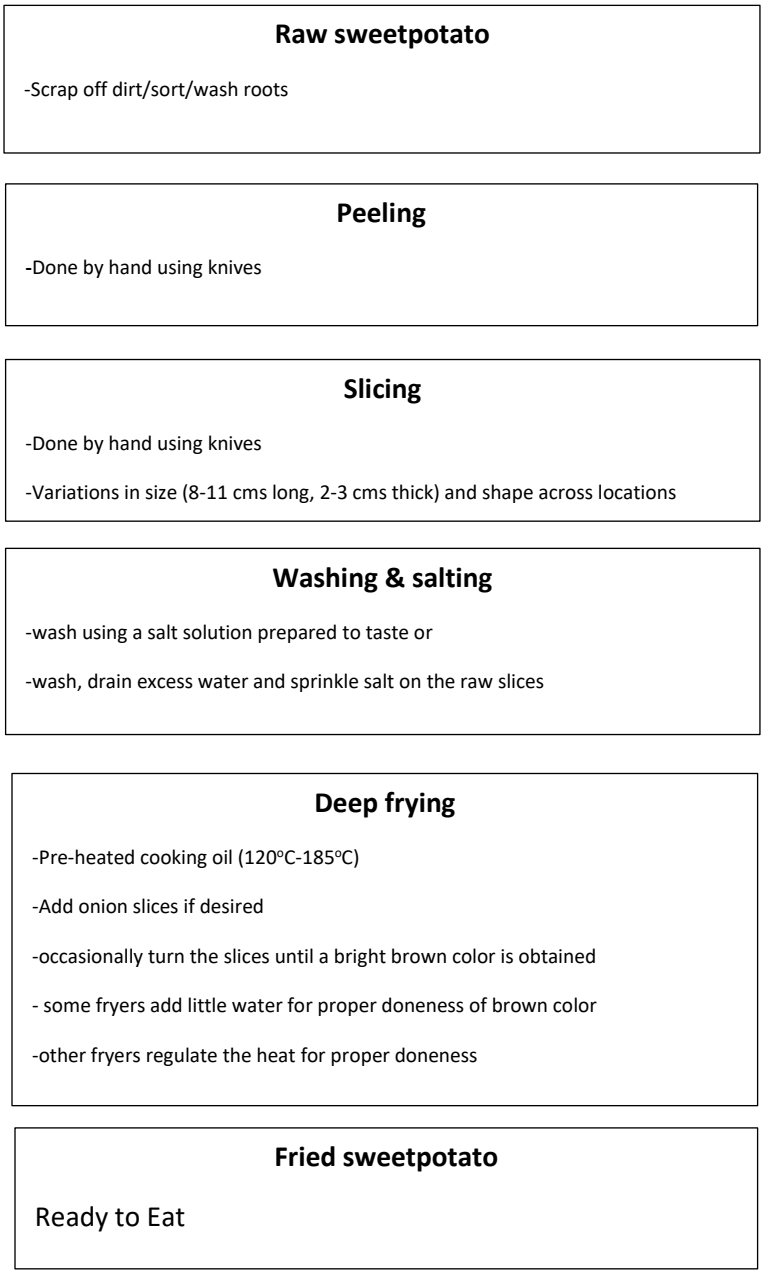

Figure 2 : General flow chart for the fried sweetpotato processing components in Ghana and Nigeria

3.2.2 Unit operations characterization

Fryer interviews indicated that the choice of variety was important in obtaining high quality fried sweetpotato products. They however agreed that frying conditions are key to produce the desired sensory properties of the final product. This is followed by washing, salting, slicing and peeling. A summary of the key units and the weighted scores of the frequencies of choice indicating their relative importance for obtaining high quality fried sweetpotato product are presented in Table 4.

Table 4 :Importance of the processing units of a fried sweetpotato

Unit Operation	Weighted scores for importance			
	Bawku	Kwara	Kano	Ranking
Peeling	2	8	5	5th
Slicing (Size of chips)	8	5	8	4th
Washing	32	40	36	2nd
Salting	32	24	24	3rd
Frying	60	60	60	1st

Table 5 :Desirable characteristics during the preparation procedure of sweetpotato for the fried final product

Characteristic	Why it is important
Hard to slice	Indicates low moisture and thus high dry matter that gives the desired end product characteristics
Does not stick to hand and not slippery	An important property during peeling and washing, and a further indication of low moisture content
Slices with uniform color	Is an indicator that the final product will also have a uniform color which is attractive to consumers
Slices with no or slight surface moisture -	Gives an indication of low moisture content and thus, high dry matter, making it easy to fry.
Slices not too sticky -	Attribute indicated as important when peeling/ slicing in Bawku. Gives an indication of low moisture content and thus, high dry matter.
Slices with no off odours	Important attribute particularly during processing (slicing). Indicates healthy roots

Table 6:Desirable characteristics of the fried sweetpotato final product

Characteristic	Why it is important
Uniform light brown colour	An indication fries are cooked: Also gives better consumer appeal; Gives an indication of *being well fried and by inference, crisp*
Uniform yellow/golden colour with a brown tint	An indication for certain varieties that fries are cooked; Also for better consumer appeal and crispness
Uniform orange with a brown tint	An indication fries are cooked for orange-flesh varieties: Also for better consumer appeal
Dry/filling/satisfying	A desired consumer attribute – an indication of high dry matter and to an extent, mealiness (just like yam); sometimes expressed as “Spreads in the mouth i.e., Mealy”
Hard/strong -at first bite	A desired consumer attribute which is an indication of crispiness
Crispy	A desired consumer attribute indicating a dry crunchy top layer of the fry
Not soggy	An indication of a dry top layer
-Not oily	An indication of varieties with high dry matter that do not consume too much oil
Moderately sugary	Sugary taste; A desired consumer attribute
-Slightly sugary	A section of the consumers also preferred this as observed from preferences for Obare (slight sugariness) and Kuffour (Moderate sugariness)

3.3 End-product processors appreciation

Table 7 :Champion fryer perspectives prior to and during diagnostic in Bawku, Upper East Region Ghana

Variety	Weighted score for preference*	Champion fryer perspectives	
		Prior to diagnostic	During diagnostic
Obare	32	Most suitable for frying	Texture just right in terms of hardness/ dryness, sweetness just right, crispy outside and soft inside
Purupuru	21	Very soft, soaks oil during frying; consumers complain it is not sweet and inside is not compact (not mealy)	Fries well and the colour change is good, however, it's too soft (moisture content high); outside not dry enough; the feel could be better if stored for a few days before processing
Kuffour	16	Too sweet, low demand with adult markets [mostly preferred by school children]; high moisture content	Irregular shape and pest damage make peeling and slicing difficult. Very sugary taste; too much moisture; consumes oil and soft. However, the final colour of cooked product is good
Amuskwera	11	Does not dry, no taste, high moisture content, has no aroma, has no flavour, low demand when fried	Good appearance when fried (brightness of colour). Hard as desired immediately after frying but softens with time.

** weighted preference scores obtained by multiplying the frequency of the fryers who ranked a variety as most preferred (1st position) by 4, and the least preferred variety by 1.*

Table 8 :Champion fryer perspectives prior and during diagnosis in Kwara State in Nigeria

Variety	Weighted score for preference	Champion fryer perspectives	
		Prior to diagnosis	During diagnosis
Pakurumo	21	Not readily available all year round and not easy to slice, but not too hard	Big root size, moderate sugariness, hard (low moisture content), satisfying when eaten (filling). Its irregular shape makes peeling difficult
Tomude	18	Does not stored well for long and darkens hands while peeling	It's easy to peel and fry, and the final color of fried product is good. It scatters well in the mouth (mealiness texture). However, it is too sugary and heavily infested with weevils
Elege	6	Thin outer skin makes it bruise easily	Moderately hard/dry, has the optimum sugar taste although it easily dehydrates if not processed immediately after harvest
Alausa	32	Available in larger quantities for a long period during the year although doesn't store for long after harvest	It is easy to peel; the final fried product has a good appearance and crispy
Aragbe	12	It is easy to peel but not hard enough	It is not filling in the mouth

Variety	Weighted score for preference	Champion fryer perspectives	
		Prior to diagnosis	During diagnosis
Mother's Delight	9	very attractive appearance after peeling but it is unfit for frying because of too much moisture and weevil damage	Fine and attractive color after frying and not too much sugar. It is not crispy, needs too much oil to fry because it consumes oil and the fried slice is too soft. It may not be bought if fried for sale

** weighted preference scores obtained by multiplying the frequency of the fryers who ranked a variety as most preferred (1st position) by 4, and the least preferred variety by 1.*

Table 9 : Champion fryer perspectives prior and during diagnosis in Kano State in Nigeria

Variety	Weighted score for preference	Champion fryer perspectives	
		Prior to diagnostic	During diagnostic
Dan China	24	Considered highly because it attains large root sizes. Remains available during the offseason but with low root quality (size and weevil damage)	Large root sizes that makes peeling easy; it leaves a sticky layer on the hands after peeling that is difficult to get rid of; its difficult to slice ;It has low exudates; short frying times; mealy and crispy when fried
Dan Izala	36	Most preferred variety because it attains big root sizes, but not very available during the offseason	It has low exudates after peeling It has short frying times, and doesn't soakoil, it is mealy, crispy, and soft after frying It has an appealing golden yellow colour after frying
Dan Barmawa	8	Attains moderate to big root sizes; easy to peel but leaves the hands gummy after peeling, and it is not readily available during the offseason	It is easy to peel, has low exudates after peeling, and produce mealy and crispy fries.
Dan Bakalori	18	Not rated highly because of small root size and slightly fibrous nature	It has an appealing root color, slightly longer frying times, less mealy and crispy when fried, and a lot of exudates after peeling.
Dan Madagali	14	Variety is only available in Bangwai during the main season. It attains moderate to big root sizes.	Peeled slices have a lot of exudates and long frying times, produces less crispy and mealy fries
Dan Silver	6	Root sizes are too small and too dry	Easy to peel, with extremely low exudates, hard to slice, short frying times, hard and very crispy fries
Mother's Delight	6	It was a completely new variety	It has the most appealing skin and flesh color, exudes a lot after peeling, long frying times, fries are not mealy, and become easily soggy.

** weighted preference scores obtained by multiplying the frequency of the fryers who ranked a variety as most preferred (1st position) by 4, and the least preferred variety by 1.*

4 DISCUSSION AND CONCLUSION

Slight differences in either size and shape of the slices, salting technique and frying temperature were observed in the processing procedures among the champion fryers across the 8 locations as

shown in Figure 2. Fryers unanimously agreed that choice of variety determined the quality of fried sweetpotato product. Raw sweetpotato roots carefully chosen for frying have a regular shape, smooth skin, big root size and no holes (indicative of weevil damage), making them easy to peel (Table 3). Previous gender mapping of processed sweetpotato products in Africa have described peeling and slicing by hand using knives as time consuming activities often done by women (Mayanja and McEwan 2015, Peters 2015). Also, fryers considered characteristics of raw sweetpotato roots that indicate the likelihood of obtaining a high quality final fried product, like the firmness of the root when pressed. Firm roots indicate low moisture content which is associated with good frying characteristics such as requiring less frying time and absorbing less oil.

Several features observed during slicing were used by fryers to gauge raw sweetpotato roots for making the desired final fried sweetpotato product. For instance, hard to slice root and little or no exudates after peeling were associated with low moisture content (Table 5). Low moisture content (high dry matter) is desirable, because it has been observed to be partly responsible for the crispiness and increased shelf stability of fried products (Fetuga *et al.* 2013, Ziaiifar *et al.* 2008). Preference for raw roots that are hard to slice suggests the need for low cost mechanization for slicing to reduce drudgery in processing fried sweetpotato. Proper washing was another major unit operation that required expert fryers to be vigilant to avoid sand in the final product. There were two distinct salting practices in both countries: washing in a salt solution prepared to taste or sprinkling salt, by hand, on raw slices during drip drying.

Deep frying was the most important unit of operation determining the quality of fried sweetpotato product (Table 4). Deep frying involves pre-heating vegetable oil (temperatures varied from 120-185°C), some fryers added slices of onions usually to determine whether the oil is ready but also to improve the flavor of the final fried product (Figure 1). Slices of sweetpotato are added and occasionally turned until a bright, golden brown color is achieved, and the oil stops bubbling, which takes around 5 minutes depending on oil temperature. Fryers had different methods of regulating oil temperature to endure the slices turned brown without burning including, adding cold water to the oil and removing fuel wood. The quality of the final fried product was defined by the appearance and the enjoyment perceived from its consumption. The attractiveness of sweetpotato final fries is partly determined by the flesh color of the raw root. Three distinct appearance preferences were reported: either a uniform light brown, uniform yellow with a brown tint or uniform orange with a brown tint. The fryers say consumers perceived enjoyment of the final fried product due to the taste (especially sugariness), crispiness and satiation after eating (Table 6).

In the Upper East region of Ghana fryers Obare was the proposed overall best variety with desirable product characteristics for use in preparing fried sweetpotato (Table 7). All attributes ascribed to Obare were associated with the eating properties of yam (particularly, varieties of Dioscorea rotundata) such as low moisture, mealiness and first crisp bite.

In Kwara State in Nigeria Alausa and Pakurumo were identified as the two most suitable varieties for raw material for fried sweetpotato products (Table 8). Mother's Delight was the least desirable variety for sweetpotato fried product for being-too soft, not crispy and soaks oil despite the desirable attribute of attractive bright orange colour. The desirable characteristics for a variety suitable for frying include, good physical appearance; big size; moderate sugariness; mealiness; disease free; smooth skin; low moisture content and void of cracks.

In Kano State in Nigeria, the two varieties that were most preferred were Dan Izala and Dan China respectively, and the two varieties that were least preferred were Mothers Delight and Silver respectively (Table 9). The expert fryer interviews, and product frying demonstrations identified important attributes/ characteristics of quality raw materials for fried sweet potatoes such as maturity, mealiness and low moisture content.

The results also show that the most preferred varieties with desirable characteristics in both countries tended to have higher dry matter content while the least preferred varieties had relatively lower dry matter content. It is recommended that this association be further investigated under WP2.

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