

State of Knowledge on Fried Sweetpotato in Nigeria & Ghana

Food Science, Gender & Market

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<u>Ethics</u>: 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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CONTENTS

Table of Contents

1	Introduction	3
2	Module I: Food Science SoK – Fried Sweetpotato	3
3	Module II: Gender and Socio-Cultural Context SoK	. 20
4	Module III: Demand SoK	.23
5	Conclusion and Recommendations	.24
6	References	.25



1 INTRODUCTION

This State of Knowledge (SoK) report brings together current knowledge obtained primarily from literature, with limited sampling of key informants. The informants include authors of several of the published reports cited here, including Bidzakin, Onumah, Peters, and David, who conducted studies in Nigeria and/or Ghana, sometimes applying a gender- and value chain-oriented lens to the assessment of needs and opportunities for sweetpotato in West Africa. In addition, experienced breeders and food scientists from within the International Potato Center (CIP) sweetpotato breeding platform for West Africa contributed their thoughts based on experience. This SoK also draws on findings from previous SoK reports developed in Uganda, which focused on both boiled and fried sweetpotato. It also complements field studies on fried sweetpotato conducted by multi-disciplinary teams including gender specialists, food scientists and agricultural economists in Nigeria and Ghana in late 2019.

The report is divided into 3 sections – I. food science, II. gender and socio-cultural context, and III. demand-assessment. A template provided by the RTBfoods project guided the information to be collected and its presentation. In West Africa, frying of sweetpotato in the form of large slices or "chunk fries" is predominant over other forms (i.e., chips (often referred to as crisps in England and the Commonwealth), and "French fries"). Our primary interest under the RTBfoods project is to develop a product profile of this product to help guide breeding efforts to ensure development of suitable new varieties. However, it is noteworthy that other fried products, particularly thinly sliced chips and French fries (like those traditionally made from potato) have received considerably more attention from food scientists, both in West Africa and internationally, than have the "chunk fries" widely sold in West Africa as a street food. Hence, section I of this review draws upon literature, mostly dealing with characteristics of these other products, with the recognition that they are a) products with significant market potential in West Africa and b) lessons learned from studies relating to the breeding of suitable varieties or techniques for the production of high quality French fries and chips may provide insights relevant to chunk fries. The forthcoming report of field studies on chunk fries in Nigeria and Ghana will address this gap in the published literature.

2 MODULE I: FOOD SCIENCE SOK – FRIED SWEETPOTATO

During the literature review, we searched for information on fried sweetpotato (including chips and French fries), with a focus on the target countries – Ghana and Nigeria – but also with a global focus to learn the state of the art. A few papers related to vacuum frying, which is done at lower temperatures and results in lower absorption of oil by the product, were also reviewed as they may have relevance to the development of healthier fried sweetpotato options in West Africa. The importance of fried sweetpotato slices as an indigenous product seems not to have been appreciated or deemed worthy of study by researchers until recently. Few reports focused on varietal assessment for suitability for chunk fry quality, or on methods to optimize chunk fry quality. In contrast there were numerous publications found on both chips and French fries in West Africa, the USA and Asia. In particular, demand for frozen French fries has created interest in optimizing quality both through variety selection and improved preparation methods.

The gender and socio-cultural context did not come up in the food science review, but will be discussed in the next section, followed by market demand. In addition to the literature review, which covers 26 publications including technical reports and literature reviews (Table 1), the SoK reports of food scientists and gender specialist from Uganda which included fried products are cited (Tinyiro, 2018; Mayanja, 2018). The most noteworthy aspects of the literature review are the lack of specific reports on chunk fries, and the high variation in preparation treatments and reported fry times and temperatures across research teams and products for both French fries and chips. Methods used by home or artisanal fryers are not described in literature, and standard processes (see figure 1) may reflect recommended practices rather than actual standard practices. The techniques of drip



drying of fries and chips is done before frying are not well documented either in Uganda or West Africa.



Figure 1: Processing steps for fried sweetpotato (Tinyiro, 2018)

According to Mayanja (2018), in Uganda fried sweetpotato is a rare product in rural areas. However, it is most common amongst the Muslim community who eat it when breaking the fast (futr) during Ramathan. The common method of preparation is peeling and slicing the root in big chunks, boiling it for a short time and then deep frying it. However, the product is fast becoming popular in urban and peri-urban markets where it is prepared and sold as a snack. Whether the parboiling process, which is among the standard practices for frozen French fries, is widely used by fryers in peri-urban markets is not known.

Relatively few of the reports truly describe requirements for raw product, though soundness of roots is an obvious requirement, and given the tendency of sweetpotato to become infested with pests and/or rot, is an extremely valid concern. Furthermore, medium-sized roots with a smooth surface are convenient for peeling and slicing. Processors are mostly exposed to important released or landrace varieties, some of which tend to oxidize and discolor during the preparation process, and lack of oxidation does not appear to be an absolutely essential characteristic of chunk fried sweetpotato in Ghana, though preparation methods for fried product require peeling and washing, which may reduce oxidation. Martin and Rhodes (1987) emphasized selection for attractive appearance before and after boiling in their identification of varieties to evaluate for suitability for chips. But they noted that the locally important cultivars were prone to discoloration. Also, informants in Ghana have observed that local varieties (including official releases) frequently tend to discolor, but that consumers tolerate this as long as other sensory aspects are satisfactory (Dery, personal communication). Furthermore, discoloration is masked to a certain extent by changes in color during frying.



Afuape et al. (2014) reported on both chunk fries and boiled product. However, no description of frying conditions was provided. Fourteen Nigerian breeding selections and released varieties were evaluated for dry matter, starch, flour yield, peel loss, followed by assessment of degree of liking of color, mouthfeel, taste, aroma and overall acceptability by a semi-trained panel. Color and taste contributed significantly to overall liking in fried sweetpotato. The orange-fleshed, low dry matter Mother's Delight was among the least preferred, but another low dry matter accession, CIP199034.1, gave the most preferred fries. Root flesh color, followed by taste contributed significantly to consumer acceptance. Differences in preference among the boiled sweetpotato samples were less marked than among fried samples, though high dry matter sweetpotatoes were generally preferred for both frying and boiling.

The other report on chunk fried sweetpotato (Sugri et al., 2012) used local varieties in Bawku, Ghana to assess consumer preference for boiled sweetpotato and chunk fries in relation to taste, color, flavour, texture, mouthfeel and overall acceptability. There appeared to be indications of preference clusters for chunk fries, with an orange-fleshed sweetpotato (OFSP) variety preferred due to sweetness and color by a significant proportion of the population, and less sweet, white-fleshed varieties preferred by others. The description of hardness and mouthfeel of preferred fries was not easy to understand since the interior and exterior of fries have different characteristics. The authors noted that differences in preference for boiled sweetpotato were masked by frying, and overall acceptance increased in fried samples.

Reviews of sweetpotato processed products by Padmaja (2009) and Truong et al. (2018) cover general practices with respect to both chip and French fry production. For chips, slices 0.8 to 2mm thick are parboiled and partially dried in forced hot air (119°C) before frying at 143 to 152°C, draining and packaging. The hot air treatment before frying significantly affects appearance, flavour and texture. Reducing sugars and amino acids in the raw material can contribute to excessive browning during frying. For frozen French fries, sweetpotato is sliced into strips roughly 0.9 cm square of varying length, and blanched in boiling water containing 1% sodium acid pyrophosphate (SAPP) to prevent oxidative browning. Strips are air dried at 120°C for 5 min (which reduces oil consumption and improves sensory qualities) and then frozen prior to frying. Sometimes they are par-fried1 before freezing. Final frying is done at ~180C, though oil temperature typically drops immediately after addition of the fries to the oil (Walter et al, 1997). In the USA, they are also typically coated with starch-based materials to improve appearance and exterior crispness.

Euro Ingredients (2018) recommended blanching whole roots for 3 minutes before peeling and slicing with their Chip-a-fry machine in order to give better final French fry quality. Oner and Wall (2012) evaluated blanching time and par-frying of purple-fleshed sweetpotato to produce ovenbaked or fried final product. The oven-baked product had 67% less oil and 27% more anthocyanin but was not quite as crispy.

With respect to health, Tumuhumbise et al. (2009) compared cooking methods of quartered OFSP roots cut into 2 cm slices, with respect to carotenoid retention and in vitro bioaccessibility. They reported loss of all-trans-ß-carotene by all cooking methods, with an increase in 13-cis-ß-carotene. Bioaccessibility was highest in fried slices, more than compensating for loss of total ß-carotene. Kourouma et al. (2019), examined effects of cooking on carotenoids and antioxidant activity of OFSP, and reported greatest losses of ß-carotene in thinly sliced crisps, with increases in 9-cis-ß-carotene from all cooking methods. Antioxidant activity increased in cooked samples, including crisps, relative to raw samples. ß-carotene retention in crisps was probably lower than in fried slices due the harsher conditions during frying of the thinly sliced crisps. Reducing sugars and asparagine in sweetpotato contribute to browning in fries, and to the production of potentially unhealthy levels of acrylamide. However, the recommended blanching with SAPP along with slightly lower fry temperature (165°C) reduced acrylamide to safe levels (Truong et al., 2014). Odenigbo et al. (2012) evaluated fried sweetpotato starch (not clear if it was French fries or chips) for predicted glycemic index (pGI) and found low to moderate pGI in the five US varieties evaluated.

¹ **Par-Frying,** used for frozen French fries, ensures that the sweetpotato is soft and fluffy on the inside. It is preceded by parboiling and drying steps.



Various studies have attempted to relate physico-chemical properties of raw and fried sweetpotato to sensory properties and consumer acceptance, particularly to assist breeding programs to select varieties that make better quality fries. Walter et al. (1997) in the USA, evaluated two soft, sweet and three less sweet, firm genotypes. Sensory preference under red lights showed textural preference for the firm types and taste preference for the soft, sweet types. The author felt that it would be possible to predict fry quality based on texture and sugar parameters without the need to resort to use of sensory trained sensory panel. Sato et al. (2018) in the USA, evaluated 16 genotypes with contrasting characteristics and found sensory characteristics were highly correlated with dry matter. alcohol insoluble solids, starch and total sugar in raw sweetpotato, and instrumental texture measurement (using a French fry rig2) of French fries, and suggested these could be used to predict fry quality in breeding programs. Lv et al. (2019) evaluated starch granule size distribution in 21 Chinese sweetpotato genotypes and reported that amylopectin content was higher in roots with a predominance of small (<2.27 µm) and medium-sized (2.27 to 17.51 µm) starch granules, compared to roots with larger (>17.51 µm). These smaller granules produced both better quality dried slices and fried crisps implying that selection for starch granule size distribution could be a means to select for superior quality.

To date, our work in the sweetpotato breeding program in Ghana has focused on French fries rather than chunk fries, except a few years ago when we used chunk frying in consumer sensory evaluation associated with on-farm and advanced trials. We assumed that chunk frying gave an adequate assessment of both chunk fry quality and an indication of boiled quality, if one only paid attention to the interior. We eventually moved to routinely assessing boiled quality because it was easier to do. Laryea et al. (2019) reported on the evaluation of 10 genotypes, including released varieties and advanced lines3. Fat content of fries varied from 14 to 24%. Three higher dry matter genotypes produced moderately crunchy fries (more yam-like), and beta-carotene loss during frying varied from 13 to 44% among the three orange-fleshed genotypes. Dery et al. (manuscript in prep) developed lexicons for French fried (no pre-treatments, fried at 180°C for 8 to 10 min) and boiled sweetpotato. The fried lexicon defined 21 traits, including appearance, texture (touch and mouth), flavour and basic tastes. Dery et al. (manuscript in prep) evaluated consumer preference for boiled and French fried sweetpotato in towns and cities in the North and South of Ghana, where sweetpotato fries (chunk fries) are widely consumed. Five varieties with contrasting characteristics were evaluated, including orange-fleshed, high dry matter, low sweet and non-sweet genotypes. Consumer preference mapping showed distinct clusters for orange-fleshed and for the low and non-sweet types. The data are being evaluated to determine possible demographic contributions to these different clusters.

Considerable research has been done on chips, which constitute a potentially important emerging product for West Africa (Table 1). Ali et al. (2012) evaluated 3 Caribbean cultivars for chip and French fry consumer preference, dry matter, etc. and reported no difference in preferences among chips (which were preferred to French fries), but reported difference among French fries, with appearance of OFSP preferred, but taste (perhaps due to lower sugar content) of the WFSP slightly preferred. Fetuga et al. (2014) looked at optimal time and temperature of frying for a commercially important YFSP in Nigeria. Fat content ranged from 19.1 to 26%, with higher contents giving preferred taste, but conditions were identified (180°C for 5 min) with lower fat content (22%) but good overall acceptability, important for reducing oil use and extending product shelf life. Nasir et al. (2019) looked at optimizing OFSP (two varieties: Mother's Delight and King J) chip production in Nigeria through evaluation of frying times and temperatures. Optimized Mother's Delight (151°C for 4.2 min) had lower sensory oiliness and greater consumer acceptance (good appearance, taste and crispness) but also had the highest oil content (30%). In Uganda, Tumuhimbise et al. (2013) in Uganda evaluated the potential for soaking OFSP crisps (varieties Kakamega and Ejumula) in salt solution before frying to improve shelf-life of fries. Carotenoid loss in salted samples was higher than in unsalted samples. Crisps made with 2% salt were most acceptable and packaged samples stored for 2 months at room temperature without quality loss. Gao et al. (2014) evaluated attributes of chips made from thirteen sweetpotato genotypes from the USA with diverse textural dry matter, starch

³ Fried samples were prepared using the following protocol: No pre-treatment, frying at 175°C for 5 minutes.



² French fry rig: a texturometer attachment to measure the force required for breaking multiple fries

properties and starch content. Lower dry matter and lower starch content gave better fracturability4 measured by texturometer, but sensory analysis was not done. Martin and Rhodes (1984) evaluated genotypes from the Puerto Rico breeding program as well as commercial varieties. Standard crispy type sweetpotato chips from bred varieties were mainly preferred. Authors also identified "cookie type" chips from higher dry matter sweetpotato (probably a type similar to the standard W. African staple types), and some potato-chip-like chips from non-sweet genotypes. However, these were not among the most preferred by the consumer panel.

Vacuum frying is a relatively new method, which allows frying at lower temperatures and in the near absence of oxygen. It results in much lower oil uptake by fried products, with better retention of nutrients and flavour, as well as longer life of the cooking oil. In India, Giri et al. (2019) reported on process optimization by response curve methodology and quality attributes of OFSP vacuum fried chips. Vacuum pressure, fry time and temperature were varied, all affecting carotene retention. Optimal conditions were determined at 110°C, 16.1 Kpa vacuum pressure, and 7 min frying time. Vacuum fried chips absorbed ~50% less oil and retained roughly 50% more carotenoid than atmosphere fried crisps. Sensory attributes were acceptable for vacuum fried chips. Chinese researchers have recently reported successful use of microwave, ultrasound and osmotic pretreatments to remove water prior to vacuum frying in order to improve quality of PFSP crisps. Su et al. (2019) reported that combined ultrasound and microwave vacuum frving improved retention of anthocyanin, reduced oil uptake by up to 30%, reduced water activity and shrinkage (extending shelflife and improving product yield), and improved crispness and color of fried product (4 mm-thick crisps) compared to vacuum frying. Fan et al. (2019) reported optimum osmotic-ultrasound dehydration pre-treatment (11.2 min ultrasound, 57% sucrose concentration, 75 min dehydration time prior to microwave vacuum frying at 90°C) gave optimal moisture absorption isotherm and water state. Vacuum frying devices equipped for ultrasound treatment, microwave heating, and centrifugal oil removal are commercially available for relatively small batch processing.

A synthesis of required attributes for quality chunk fries in W. Africa based on key informant interviews (KIIs) and literature is presented in Table 2, while Table 3 presents the characteristics of preferred sweetpotato chunk fries in Uganda based on SOK of Tinyiro et al. (2018). Attributes of a good fried sweetpotato in Uganda appear to be the same as those required in West Africa.

⁴ Fracturability or brittleness is the tendency of a material to fracture, crumble, crack, or shatter upon the application of a relatively small amount of force or impact. Lower peak break force values are preferred.



Table 1. Literature reports on fried sweetpotato with information extracted on product (crisps, French fries or chunk fries), data presented and key findings.

Reference	Country	Number of genotypes + types	Product(s), pre-treatment ; frying conditions	Data presented	Key finding
Afuape <i>et al.,</i> 2014	Nigeria	14 (OFSP, WFSP, YFSP)	Fried slices (chunk fries); Boiled (methods not detailed)	Proximate (dry matter (DM), starch) Preference for sensory attributes	Lower DM preferred for fry (color and taste contributed) Higher DM preferred for boiling (color, mouthfeel and aroma contributed) Released OFSPs Mother's Delight (MD) and King J, not preferred for either, though King J ranked better than MD for both.
Ali <i>et al.</i> , 2012	UWI, Trinidad	3 ; 1 OFSP, 2 WFSP	French fries (7x1.9x0.64mm) and 1 mm chips; none ; 185°C for 5 min	Various proximate and starch attributes. Preference for sensory attributes	Preference for OFSP French fry appearance, but preference for WFSP taste and texture. No differences in cultivar preferences among chips.
Dery, <i>et al.</i> , In prep.	Ghana	> 30 breeding lines and varieties	French fries of varied length. 0.7 x 0.7 cm. Deep fry @180°C for 8 to 10 min, and then drain on paper towel 2 min before wrapping with aluminum foil prior to serving.	Trained sensory panel to develop validated sensory lexicon	Lexicon attributes : Appearance (4), texture to touch (3), texture in mouth (4), flavor (6), basic tastes (4)
Dery <i>et al.</i> , in prep	Ghana	5 breeding lines and varieties	Same as above	Consumer preference assessment in northern and southern towns where sweetpotato is important, and in the capitol city where exposure varies; complemented by trained panel assessment.	Consumer preference mapping showed distinct clusters for OFSP and less sweet W+YSP. Demographic basis of these differences appears to be regional.



Reference	Country	Number of genotypes + types	Product(s), pre-treatment ; frying conditions	Data presented	Key finding
Euro- Ingredients, 2018			French fry instruction manual for hand cranked fry cutting machine		Recommend blanching whole roots for 3 min, drain and cool. Peel before chipping. Slice using Chip-A-fry. Fries can be kept in covered bucket (no need to add water) until fried at 172 to 190°C. Don't use same oil for more than 3 batches
Fan <i>et al.,</i> 2019	Jiangnan U, Wuxi, Jiangsu, China	PFSP from the supermarket	4 mm thick chips , given pre-frying ultrasound (40 kHz, 250W, intensity of 14.6 W/I) for 0, 10, 20 or 30 min @25°C and osmotic dehydration for 60, 90 or 120 min @50°C. Osmotic solutions were sucrose at 30, 45 or 60% w/w. Microwave assisted (1000W) vacuum (0.09 MPa) frying @90°C for 15 min in soybean oil for samples from optimized osmotic- ultrasound dehydration treatments. Fried samples centrifuged to remove oil	Response surface methodology was used to evaluate effect of process variables on water loss and solid gain. Moisture adsorption isotherms of pretreated and untreated fried PFSP sliced measured and modeled. Water state of fried slices determined by low field nuclear magnetic resonance (LF-NMR)	Osmotic-ultrasound dehydration pretreatment improved moisture adsorption isotherms and water state of fried product during storage
Fetuga <i>et al.</i> , 2014	FUNAAB, Nigeria	1 YFSP from market	1.2 mm chips , blanched in 1% NaCl for 2 min, drained and fried; temps from 150 to 180°C for 3-12 min	Moisture, protein, fat, crude fiber, ash, carbohydrate; sensory preference rating of taste, color, flavor, crispness and overall liking	Fat content reduced with temperature and cooking time increase. Overall acceptability affected by taste (r=0.93)>flavour (r=0.90)>color (r=0.89)>crispness (r=0.78). Higher fat content gave preferred taste, but 180°C for five min gave good taste, though best was 170°C for 8 min for better overall acceptability and lower fat – important for rancidity and oil use.



Reference	Country	Number of genotypes + types	Product(s), pre-treatment ; frying conditions	Data presented	Key finding
Gao <i>et al.</i> , 2014	Mississippi, USA	13 ; (OFSP, WFSP, YFSP)	1 mm chips ; Control (slices in cold water) + blanching (chips blanched for slightly acidic salty boiling water for 3 min – chilled for 5 min and dried for 4 hours). Cooking at 190°C for 1 min	Texturometer (fracture, puncture and penetration) tests; dry matter, starch and starch properties	Lower dry matter and lower starch contents gave better fracturability. Penetrometer ratings correlated closely with fracturability (30 reps); no sensory evaluation done.
Giri et al., 2019	CTCRI, India	OFSP ST-14 (30% dry matter, carotenoid 9mg/100g)	1 – 2 mm slices (crinkly chips). Process optimization by response surface methodology using vacuum frying apparatus, and varying frying time, frying temp, and vacuum pressure.	Moisture and oil content, carotenoid content of raw and fried crisps, color and texture (instrumental)	Optimal conditions determined to be 110°C, 16.12 KPa vacuum pressure, and 7 min frying time. Optimize vs atmosphere fried: moisture (9.1 vs 15.4%), oil content (12.3 vs 22.8%), carotenoid (6.8 vs 4.3 mg/100g), color change (20.1 vs 25.0 \triangle E), and texture (1.27 vs 4.37N)
Kourouma <i>et</i> <i>al.,</i> 2019	CAAS, Beijing, China	Pushu 32 OFSP from Hebei	SP "cut into pieces" and boiled , steamed, microwaved (1150W) for 15, 25, 35, or 45 min. Whole SP roasted @190°C fir 15, 25, 35 and 45 min. SP "cut into thin pieces" and fried @160°C for 1, 1.5, 2 or 2.5 min.	Proximate composition, carotenoids, vitamin C, antioxidants	Frying reduced ß-carotene content by 80% or more, while other forms of cooking were not as drastic. 9-trans- ß-carotene increased during cooking, with greatest increases in fried product, but did not approach levels of ß-carotene lost. Increased (9Z)- ß- carotene contributed to antioxidant activity. Fat content of fried product increased. The very high loss of ß- carotene might be due to fat solubility.



Reference	Country	Number of genotypes + types	Product(s), pre-treatment ; frying conditions	Data presented	Key finding
Laryea <i>et al.</i> , 2019	Kumasi, Ghana	10, including W,Y,P and OFSP Ghana elite lines	French fries 0.7x0.7x7.5cm ; Cut, rinsed, patted dry and fried at 175C for 5 min.	Moisture, fat, color, beta carotene of fries; Descriptive sensory for color, crunchiness, hardness, moisture, sogginess, caramel, starch/rawness and oily mouth coat	Fat content of fries varied from 24% (CIP442162) to 14% (CRI- Dadanyuie);TU-Purple, Bohye and CIP440390 produced moderately crunchy fries and had highest score for desired attributes compared to other genotypes (more yam-like). Loss of beta-carotene during frying varied from 13% (Nan) to 44% (Bohye); Apomuden lost 30%.
Lv et al., 2019	Zhejian A&F U., China	21 genotypes	Chips from washed, peeled, 2 mm slices; boiled in water for 1 min, fried in palm oil 140°C for 4 – 6 min. Dried sweetpotato cut into strips 1 x 1 cm and baked @50°C till 15 to 25% moisture.	Starch, amylose and amylopectin content in raw roots, particle size, texture analysis of dried sweetpotato, sensory analysis of crisps (trained panel, but hedonic rating) and product yield	Starch granules divided into small $(<2.27\mu m)$, medium $(2.27 \text{ to } 17.51 \mu m)$ and large size $(>17.51 \mu m)$. Superior quality of dried sweetpotato and chips was obtained from genotypes with a higher proportion of small and medium size granules. Small size granules had a greater proportion of amylopectin, while larger starch granules were higher in amylose.



Reference	Country	Number of genotypes + types	Product(s), pre-treatment ; frying conditions	Data presented	Key finding
Martin and Rhodes, 1984	Puerto Rico	>310 seedlings screened ; 55 of these selected based on initial screening, and evaluated along with 27 cultivars or breeding lines;	Seedling roots cut and discoloration rated after 15 min. Seedling roots boiled 18 min and evaluated. Selected roots along with cultivars and breeding lines were boiled or fried (1 mm chips were fried in soybean oil @177°C for 4 min.) drained and placed on paper towels	Seedlings classified for oxidation, flesh color, boiled hardness, mouthfeel, sweetness and overall rating and classified into classes based on orange flesh color (not anthocyanin), mouthfeel and sweetness and rating of boiled roots. Selections, cultivars and breeding lines were evaluated independently for various sensory traits and acceptability by a 5-member, small trained panel	25 of 27 theoretical combinations of color, sweetness and mouthfeel were found in the seedlings. Reasons for rejection of most seedlings were mainly related to discoloration – khaki, gray or non-uniform color. Among the 10 top-rated crisps six were or selections from NCSU, mostly orange, but some few were white. Chips mainly appeal to people on basis of flavor and crispness; seven of top ten were orange, others were cream or white. Authors referred to cookie type chips with rich flavor and potato chips. Though they were not in the top 10, there were genotypes that were good for potato-like chips.
Nasir <i>et al.</i> , 2019	FUNAAB, Nigeria	Mother's Delight (MD) + King J (KJ)	1-2 mm hand sliced chips ; no pre-treatment ; frying according to central composite design response surface methodology varying time (2.4-6 min) and temp (136-164C) at 5 levels each	Carotenoids, color, sensory quantitative descriptive analysis for color and texture ; and consumer acceptability analyzed	Optimized Mother's Delight crisps had lower sensory oiliness(?) and higher consumer acceptance. MD optimum at 151.27°C/4.2 min and for KJ at 146.36°C/4.2 min, MD chips had lower moisture content (2.85%), higher oil content (30%), carotenoids, orange-flesh color and crispness



Reference	Country	Number of genotypes + types	Product(s), pre-treatment ; frying conditions	Data presented	Key finding
Odenigbo et all, 2012	Quebec, Canada	Five US cultivars	French fries(?) dimensions not specified but described as discs, fried at 180C for 5 min	<i>In vitro</i> starch digestibility, resistant starch, moisture, ash, protein, fat. Predicted glycemic index (pGI)	White Travis and Ginseng Red (OFSP) had higher beneficial starch fractions (resistant starch and slowly digestible starch) and lower pGI even though they had higher total starch. All genotypes were low to moderate pGI
Oner and Wall, 2012	Hawaii, USA	Okinawan	French fries 9.5x9.5x50mm held in water till, blanching for 0, 5 or 10 min in boiling water and cooled in tap water 5 min and drained for 1 min; par frying for 0 or 1 min at 180C; frozen -20°C; fried at 180°C for 3 min or baked at 180°C for 8 min.	Texture analysis (force required to puncture surface), color, moisture, oil, anthocyanins, Semi- trained panel sensory analysis for flavor, texture, appearance and overall quality.	PFSP fries blanched for 10 min, no par-frying and frying had highest sensory preference. Oven baked samples blanched for 10 min, par- fried for 1 min had 65% less oil content and 27% more anthocyanin, and also had good sensory quality (just not as good texture).
Padmaja, 2009	Review		Section on chips and French fries		Crisps : Low dry matter in fresh slices leads to high oil content in fried chips. Partial drying of blanched chips reduces this along with blistering. French fries: Blanching in 1% SAPP solution, prior to frying and freezing. Crispness improved by 30 min soak of blanched slices in 1% citric acid, surface drying and frying. Low oil content can be achieved by blanching for 3 min in boiling 0.25% SAPP and 0.25% CaCl2 and par-frying at 180°C for 20 sec.



Reference	Country	Number of genotypes + types	Product(s), pre-treatment ; frying conditions	Data presented	Key finding
Sato <i>et al.</i> , 2018	NC, USA	16 genotypes with a range of attributes	French fries. Whole roots tempered in tap water for 45 min @ 70°C, then cut into 0.9x0.9xcm, blanched for 7 min @75°C, air dried for 10 min@65°C, par-fried for 75 seconds (s) @ 185°C, excess oil removed on paper towel, frozen -20°C till fried for 150s @175°C.	Fresh samples (DM, alcohol insoluble solids (AIS), starch, sugars, amylases); fries (moisture, oil, AIS, starch, total sugar; texture analysis (peak force - puncture, overall hardness – French fry rig), Sensory panel (for attributes in 5 classes)	Variations in sensory texture properties were significantly correlated with chemical components or raw sweetpotato and instrumental texture measurement of French fries. Sensory characteristics (overall hardness, fracturability, outer crispness, inner smoothness, and inner moistness) were highly correlated with DM, AIS, starch and total sugar in raw sweetpotato. The French fry rig was the best texture measurer. Can be used in breeding to predict fry quality.
Su <i>et al.</i> , 2018	Jiangnan U., Wuxi, Juiangsu, China	PFSP from market (29.6 % dry matter)	Round chips 30 mm diameter and 4 mm thickness. Blanched for 3 min @90°C, then rinsed under cold water for 1 min and wiped dry with paper towel. Fried from in increments of 2 min (2 to 16 min in increments of 2 min) to final moisture content of 0.04 kg water/kg solid @90°C using: vacuum frying (VF) @10 KPa; 28 kHz ultrasound (US) @600W combined with VF (USVF); 2450MHz microwave (M) @800W combined with VF (MVF); or combinations of US, M and VF. Chips were centrifuged to remove oil	Drying kinetics, dielectric properties, moisture state variation using NMR, surface temperature, oil uptake, texture (hardness), shrinkage, color parameters, water activity, total anthocyanins, and scanning electron microscopy of crisps	The combined US-MVF process markedly increased moisture evaporation rate and moisture diffusivity compared to the VF process. Oil uptake was reduced by 16 -34%, water activity and shrinkage were lowered, and texture and color of fried samples improved. Higher US- MVF power level made greater improvement. US600M800VF gave highest anthocyanin levels and retention (80%). SEM revealed more porous and disrupted microstructure in these samples.



Reference	Country	Number of genotypes + types	Product(s), pre-treatment ; frying conditions	Data presented	Key finding
Sugri <i>et al.</i> , 2012	Bawku, Ghana	Seven local varieties including W and OFSP	Boiled or fried lamellas (chunk fries) 3cm x 6 cm	Some root measurements, skin and flesh color; Consumer sensory using hedonic scale for taste, color, flavor, texture, mouth feel, and overall acceptability ; preference ranking and reasons. Kendall's concordance analysis to independence of variables	Color, aroma, taste and mouthfeel of the OFSP variety Cinkanse-Abiga was liked, while hardness of the WFSP varieties was preferred. Differences among varieties were masked by frying compared to boiling, and overall acceptability of fried SP was higher. Reasons for preference and non-preference appear to indicate preference clusters for sweetness, texture, and differences between fried and boiled. Hardness is a bit ambiguous for fries since the exterior and interior of the root have different preferrent textures.
Truong <i>et al.</i> , 2014	NC, USA	Covington cured and stored 4 months	French fries 0.9 x 0.9 x 9 cm ; Pretreatments: 1. no pretreatment (before frying or par-frying and frying), 2. blanching for 3 min in water @ 95°C, then soaked for 10 min in 0.5% sodium acid pyrophosphate (SAPP), and tap water for 10 min @21°C then air dried for 10 min @65°C; 3. Same as 2, but with 0.4% CaCl2 soak for 10 min @ 62°C before air drying. Strips par-fried for 1 min @ 165°C in canola oil, frozen and then fried for 2,3, or 5 min @165C.	Dry matter, sugars, asparagine, calcium, acrylamide	Pre-treatments reduced acrylamide levels by 10-fold. Untreated fries cooked for 2 min had 125 ng acrylamide/g product (recommended for potato which can range from 60 to 1800 ng/g), but this increased to 452 ng/g after 5 min. 165°C oil temp was recommended to avoid excessive browning.



Reference	Country	Number of genotypes + types	Product(s), pre-treatment ; frying conditions	Data presented	Key finding
Truong <i>et al.,</i> 2018	Production, processing and nutritional quality	Review	Chips and French fries, etc.		Crisps : sliced 0.8-2mm., blanched for 2 min at 93°C, drained and partially dehydrated in forced hot air at 119°C. Optimum frying between 143 and 154°C. Vacuum frying at lower temp and de-oiling by centrifuge gives good quality, low fat. Chips then drained and salted. French fries: Raw slices blanched in boiling 1% SAPP solution, partially dried at 120°C for 5 min, frozen for storage prior to frying. Partial drying reduces oil absorption and improves sensory quality.
Tumuhumbise <i>et al.</i> , 2009	Uganda	5 OFSP varieties including Ejumula, Kabode, Vita and Kakamega, plus SPK004/1	Sweetpotatoes were peeled, quartered and opposite quarters cut into slices 1.5 to 2 cm thick. Slices were boiled for 20 min, wrapped in banana leaves and steamed for 30 min, fried in 170°C sunflower oil for 10 min or baked @180°C electric oven.	HPLC analysis of carotenoids, <i>in vitro</i> bioaccessibility of ß- carotene, and microstructure analysis	Boiled, deep fried and steamed retained more <i>all-trans</i> ß-carotene compared to baked samples for all varieties. Higher levels of 13- <i>cis-ß</i> - carotene in processed than raw with levels in proportion to initial <i>all-trans</i> ß-carotene levels. <i>All-trans-ß</i> - carotene was the predominant carotenoid in all samples. 13- <i>cis-ß</i> - carotene was the only trans isomer detected. Deep frying provided greatest bioaccessibility, with over 50% and raw was lowest with ~20%.



Reference	Country	Number of genotypes + types	Product(s), pre-treatment ; frying conditions	Data presented	Key finding
Tumuhimbise <i>et al.</i> , 2013	Uganda	OFSP- Kakamega and Ejumula	Chips 3.5 mm slices ; soaking for 10 min in 0, 2 or 4% salt solution, drained and fried for 5 min at 180°C. Stored in paper-lined low density polyethylene bags for 3 months in the dark.	Beta-carotene, protein, fat, moisture content; semi-trained sensory panel evaluated color, taste, crispness, mouthfeel and overall acceptability on a hedonic 9 point scale	Carotenoid loss during frying was greater in salt treated samples. Chips treated with 2% salt were most acceptable. Freshly made Ejumula was better than Kakamega, but they were equal after two months of storage, with acceptability of Kakamega having increased. After three months, quality was reducing, but 2% salt-treated crisps were still rated highest. Non-salt-treated had highest storage stability.
Ukpabi <i>et al.</i> , 2012	Nigeria	4 OFSP and 1 yellow introduced, but clear misidentifications since some known WFSP were listed as OFSP	Chips sliced mechanically at 1 to 2 mm, salted (no description) and deep fried at 140 to 150°C for 2 to 3 min.	Dry matter content, beta- carotene of raw and fired chips, peel loss. 20 semi-trained consumer panelists used a 7-point hedonic scale to rate for crispness, sugariness, and overall acceptability	The most acceptable chip scored 4.3 on a 1 to 7 scale. It was also preferred for sugariness and crispness. Discoloration of chips was a problem with one genotype. Dry matter content ranged from 21 to 38% with the best genotype reported to have 36% DM.
Walter <i>et al.</i> , 1997	NCSU, USA	2 sweet, soft 3 less sweet, firm	French fries : 0.9 x 0.9 x variable length from cured, stored roots. Blanched in boiling 1% SAPP, air drying and freezing prior to frying. Frying at 180°C for 3 min (oil temp dropped to 150 and ended at 155°C) ; Fries drained for 30s and put in paper-lined containers covered with aluminum foil and held at 60°C until evaluated within 15 min. Shear force measured on room temp samples.	DM, sugar, AIS, % intercellular space (SG) by vacuum method, cell size by microscopy, pectic substances, oil content, shear force, Sensory texture-flavor profile trained panel (4 taste notes, 7 texture notes); preference panel (under red light) for flavor, texture and overall	Texture of the firm ones was preferred, while flavor of the sweet- soft selections. Looked at correlations and found some, but further work needed to develop a system for prediction of fry quality based on instrumental analysis.



Table 2. Overview table of quality characteristics for fried sweetpotato in Ghana and Nigeria

	Quality Characteristics (and range, if possible) to achieve a good product * specify variation with process/region/user group – complete multiple tables if necessary	Mean ranges for the quality characteristics	Evidence to substantiate	Your confidence in the information (low, med, high) + reason
Raw material	Smooth medium sized roots, easy to peel. No rots or insect infestations. "Mature" roots that do not exude excessive latex, perhaps indicative of a few days post-harvest	Some tolerance for root size, uniformity, rots and insect infestations, which can be removed, but there is strong selection for the ideal in commercial varieties. There is also a general preference for large size roots because of their commercial demand, which contrasts with consistent preference for medium sized roots by fryers.	David and Madu, 2015 (Table 4 below) and Peters, 2015 (Table 5 below) stress the importance of shelf-life and lack of weevil attack.	High, though not certain of meaning of mature
Processing/Preparation steps				
1	Smooth, easy to peel without excessive peel loss.	Processing loss due to poor shape is very undesirable, but has been tolerated in some cases where smooth roots are not available	Not widely documented, but supported by general consensus among key informants	High
2	Firm easy to slice roots, no evident fiber or internal cavities and/or discoloration	Firmness is closely related to freshness/shelf-life. Sweetpotato is high in dietary fiber, but there is little tolerance for woody fibers which can occur rarely. Internal cavities or other storage root quality disorders are unacceptable, and can occur rarely in some commercial varieties	David and Madu, 2015 (Table 4 below) and Peters (2015) related to shelf-life	High
3	Bright appearance; no major discoloration prior to frying (though some may be acceptable)	Discoloration is common both before and after cooking, but can be tolerated at an artisanal level, though undesirable. Further, browning during frying can mask discoloration.	Laryea <i>et al,</i> 2019; personal communication Eric Dery	High



Processing/Preparation steps	Quality Characteristics (and range, if possible) to achieve a good product * specify variation with process/region/user group – complete multiple tables if necessary	Mean ranges for the quality characteristics	Evidence to substantiate	Your confidence in the information (low, med, high) + reason
4	Limited oil absorption during frying process; high oil absorption has been reported by fryers as a common reasons for rejecting low dry matter OFSP genotypes	Consumers, particularly in West Africa, like oil, so oily product is not automatically considered objectionable, but it must have other quality attributes listed below in the finished product. However, use of oil during frying is economically important to fryers, and probably also reduces length of time crispness of the product is retained following frying. Further, reduced oil in fried products is desirable in a healthy product, hence the search for vacuum fried crisps, etc.	Anectdotal evidence from fryers, as well as some citations in this review (Fetuga <i>et al.</i> , 2014; but this is for crisps, not French fries). Laryea <i>et al.</i> 2019 reported highest oil content in a higher dry matter genotype. Truong <i>et al.</i> 2018 reported on desiccating treatments such as blanching that reduce oil absorption.	Moderate
End product	See below.	As with all foods, there is some tolerance for fries that are not perfect. Excellent fries, conforming to the parameters described below are the product of both the raw sweetpotato and the techniques and conditions that are used during preparation.	From Uganda SoK (Tinyiro, 2018), corroborated by KIs and consensus knowledge in West Africa. In West Africa there seems to be a preference for less sweet flavor notes, particulary in southern areas, but this needs to be corroborated by research.	High

Table 3. Characteristics required of good quality fried sweetpotato in Uganda (from Tinyiro, 2018)

Characteristic	Requirement/specifications		
Color	Light brown fries		
Texture	Crispy surface		
	Soft and slightly dry interior		
	Mealy texture/mouthfeel		
	Not fibrous		
	A little crunchy		
Taste	Characteristic sweetpotato sweetness		
Aroma • Fried sweetpotato aroma			



3 MODULE II: GENDER AND SOCIO-CULTURAL CONTEXT SOK

This part of the review relies mainly on literature as well as general knowledge of the role of women in sweetpotato farming (and farming in general in Ghana and Nigeria). Various publications on sweetpotato and its utilization in West Africa are cited, with notes on whether attention was paid to utilization or to gender.

Sweetpotato in West Africa has largely been an orphan crop from a policy perspective since it does not rank among the top five food crops in most West African countries. For example, according to FAO (2018) in Ghana it is ranked eighth in terms of area and twenty-second in terms of production among crops, while in Nigeria it is ranked as tenth in terms of both area and production. This despite Nigeria being ranked second globally in area under production and 3rd or 4th in production per se. According to FAO, Ghana ranks eighteenth in terms of area and thirty-ninth in production. However, these FAO statistics for sweetpotato are almost certainly wrong as they indicate yields of around 2 t/ha for both Nigeria and Ghana, which are far too low to be of commercial or even household food security interest to many farmers. Indeed, according to a Ghana agricultural statistics survey done in 2012 (MoFA-SRID, 2012) reported total production of 131,990 t, more or less in line with FAO statistics, but produced on a much smaller area, 9662 ha, with an estimated mean yield of 13.7 t/ha.

The crop has received some investment, both in Ghana and Nigeria, based largely on appreciation that sweetpotato, particularly OFSP, is a nutritional powerhouse that can help to combat vitamin A deficiency, a widespread public health problem with devastating effects on the normal development of children under the age of five. Significant investments by the Bill & Melinda Gates Foundation enabled the establishment of a regional sweetpotato breeding platform in Ghana by CIP in 2010 with a focus on breeding for regional adaptation and quality attributes, and also worked to establish commercial demand and seed systems for OFSP in Ghana, Nigeria and Burkina Faso. Investments by other donors (such as USAID and the Government of Canada) have specifically introduced OFSP in programs to improve livelihoods and empower women, including the Resilience in Northern Ghana (RING) and GROW projects. Sweetpotato has also benefited from IFAD- and World Bank-assisted government investments in root and tuber crops in both Nigeria and Ghana, which focused primarily on cassava and yam, but provided limited support for sweetpotato.

References to gender roles in sweetpotato production and utilization in West Africa are sporadic, as is information on the importance of frying and other forms of utilization. Akoroda (2009) in a review of sweetpotato in West Africa, did not mention gender, but did mention common forms of utilization including boiled, fried, roasted, and drying to prepare flour. Sam and Dapaah (2009) reported findings from a baseline survey for the West African Agricultural Productivity Programme (WAAPP) in Ghana. Thirty percent of respondents were female, with a lower proportion in the northern part of the country, where women have a harder time entering into agriculture due to cultural constraints. The report focused more on the potential of sweetpotato than on current utilization, but did mention suitability of the eight varieties released at that time by CSIR-Crops Research Institute for end uses, including boiling (seven out of eight) and frying into chips or French fries (four out of eight). In an adoption/impact study at the end of the of the WAAPP of sweetpotato varieties released in Ghana, Acheampong et al. (2017) reported that, though women were only 16% of those surveyed (only 3% in the northern areas surveyed), they were more enthusiastic adopters of improved varieties. This report did not mention information on utilization but presented an updated list of 12 released varieties with recommendations on utilization; 8 of the releases were classified as excellent for frying, while 11 were classified as suitable for "ampesi", a firm, boiled product. Only the one low dry matter OFSP was not recommended for either of these uses, but for softer traditional dishes.

Bidzakin et al., (2014) conducted a Rapid Rural Appraisal in 3 regions (2 communities per region) of northern Ghana but did not present gender disaggregated results. There was no mention of



utilization, but producers identified market demand and postharvest perishability as two major and interrelated concerns. It is well known that there are barriers to women engaging in agriculture in northern Ghana (and northern Nigeria), including traditional taboos, and prevailing conservative Islamic strictures. However, women tend to have responsibility for household gardens, and sweetpotato is an interesting crop to them. Gender intentional efforts under a MEDA project in the Upper West Region have successfully encouraged female entrepreneurship, as have efforts under a USAID project called Resilience in Northern Ghana.

Onumah et al. (2012) conducted a value chain investment feasibility study focusing in Nassarawa, Osun and Kwara States in Nigeria, and looked at current and potential forms of utilization. Most marketed sweetpotato went for household consumption, boiled or fried. Also, there was considerable processing into dried chips or other traditional products (elubo5) at the household level. Bland yellow-fleshed varieties predominated due to preference by roadside chips/chunk fries makers for high dry matter (reduced oil absorption compared to lower dry matter varieties) and attractive appearance. Potential markets for chips, frozen French fries, puree and school feeding were identified. There were misconceptions about health effects related to sweetness that constrained demand. Sweetpotato was considered profitable because of its rapid and high production. There was a ready market for sweetpotato as it was comparable to yam in terms of production and utilization, and accessible to the poor when yam was unaffordable. Chunk fries were identified as an excellent entry point for women given the low cost for entry into fried product production, and high profit margins.

David and Madu (2014) conducted a situation analysis of gender in sweetpotato production done in 3 States with contrasting ecologies from north to south in Nigeria. Gender differences were not found in variety preferences. OFSP was largely unknown in the communities studied. Women and men mentioned quality attributes equally in their listing of preferred varietal attributes. Sweetpotato was becoming more commercialized and variety diversity declining as better performing varieties were quickly adopted. Frying was one of the important uses mentioned at each location, and multi-purpose varieties were preferred. Preferred variety characteristics are summarized by state in Table 4. Other important uses varied by location with incorporation into cassava fufu6 (0.25:0.75), dried chips milled into flour for use in amala7 or sweetening in kunu8 (sweet beer) all important. The crop was used for both household consumption and sales (over 50% in most cases), though more detailed surveys were recommended.

David (2015) reported on barriers to entry by women into sweetpotato production in six communities in Kwara and Nassarawa states in Nigeria, where the crop is traditionally a "man's" crop. [Selected results from the survey of David and Madu (2014).] No mention was made of utilization, but variety diversity in the two study areas had reduced in response to increased market opportunities. The crop was mentioned as a good source of income because of early maturity, high yields and marketability. The study found that sweetpotato was generally a more important source of income for women than for men, but women in the study locations faced gender-related structural constraints in crop production that are likely to restrict them from engaging in medium- or large-scale production.

Bidzakin et al. (2017) reported on a gender study in six communities in Northern and Upper East Regions (NR and UER) of Ghana by a multi-disciplinary team under the Gender-responsive Researchers Equipped for Agricultural Transformation (GREAT) program. The team interviewed producers, traders and consumers about varietal preferences using quantitative (individual interviews) and qualitative approaches (gender disaggregated focus group discussions). Fifteen male and ten female producers, five male and five female traders and five male and five female consumers were interviewed in each of six communities. There were striking differences in cultivar

⁸ Kunu is a popular sweet drink in northern Nigeria, which can be made from millet, soghum or maize



⁵ Elubo is a flour normally made from peeled, fermented yam or cassava slices, but can be made from sweetpotato

⁶ Cassava fufu is a reconstituted product made from elubo flour from fermented cassava pieces after a few days fermentation.

⁷ Amala is a reconstituted product made from flour from dried yam chips

preference by value chain actors between NR (Apomuden, an OFSP, preferred) and UER (Obare, a WFSP, preferred). Women and men largely agreed on desired traits with a greater concordance among men than women. Apomuden is a low dry matter, high yielding OFSP, promoted in the Northern Region under various projects. Obare is a high dry matter white-fleshed variety, important in the area surveyed of the Upper East Region around Bawku, where there is a significant commercial export market to Burkina Faso.

Bidzakin et al. (2017) did not specifically mention forms of use. However, knowledge of health benefits of OFSP played a large role in variety choice in the Northern Region. Traits ranked highest for preferred varieties by both male and female producers were taste and yield, while women mentioned quick cooking time and men mentioned earliness. Varietal traits ranked highest by female traders/aggregators were price, white flesh color and cooking time, while males ranked price, orange flesh color and cooking time highest. [These results are somewhat difficult to interpret since equal numbers of male and female traders were reportedly interviewed in each region, and the regionally preferred varieties were markedly different across regions, with OFSP predominating in NR and WFSP in UER.] Among consumers, females ranked nutrition, taste of leaves, and price as preferred traits, while males ranked nutrition, cooking time and orange flesh color as their preferred traits. Key constraints listed by producers were pest and disease, lack of storage techniques, cost of inputs, while marketers ranked perishability, lack of good marketing channels, and transport as major concerns. Consumers ranked perishability, lack of storage techniques and sweetness (too sweet) as major concerns. Again, there was general agreement among men and women, but the findings did not provide guidance on fry quality.

Nassarawa State, Nigeria	Kwara State	Ebonyi State	
High root yield	High yielding	High yielding	
Large roots	Early maturing	Produces many roots	
Marketability	Storability (does not	Early maturing	
Short maturity period	spoil/rot quickly)	Grows in any soil	
High vine yield	Not easily attacked by	Marketable (high price)	
White flesh color	insects or rodents	High dry matter ("solid	
Resistance to	• Sweetness (sweet, not too	like yam")	
pests/diseases	sweet)	• lasty	
 Tasty (not too sweet) 	Sticky when pounded	Multi-purpose (good for fming and nounding)	
High dry matter content	Large roots	Trying and pounding)	
Low oil absorption when	Smooth skin, easy to peel	Shells good when cooked	
frving (believed to be	Marketable	Does not produce das	
associated with high dry		Quick cooking	
matter content)		White flesh color (so it	
		can pounded with	
		cassava)	
		Does not change color	
		when cooked	
		Does not soak up oil	
		when fried	
		Not too sweet	
		Good for feeding goats	

Table 4. Summary of preferred varietal characteristics by male and female farmers interviewed in 9 communities where sweetpotato is important in 3 states in Nigeria (David and Madu, 2014).



4 MODULE III: DEMAND SOK

Some market information was covered in the previous section. Literature on sweetpotato markets in West Africa is very thin, partly because of the traditionally low priority given to sweetpotato by policy makers. As already noted, agricultural statistical services do not routinely collect information on sweetpotato. However, it is noteworthy that there are regions and communities (enclaves; personal communication, M. Akoroda) where sweetpotato production has grown significantly in recent years, serving large markets that have developed organically, largely without research support of policy interventions. Further, markets are not static, and market studies done a few years ago may not reflect current reality. The number of studies of sweetpotato in Kwara State, Nigeria, is probably an example of this, as production in Kwara State has clearly been surpassed by areas in Kano and Kaduna with access to irrigation for year-round production.

Adeonyu *et al.* (2016) studied determinants of sweetpotato value addition among 163 smallholder households in Offa and Oyun LGAs in Kwara State where sweetpotato is important. Seventy five percent of the interviewees were male. The value addition activities were: 44% households slicing and drying, 39% slicing, drying and milling, 15% making fried chips, and 3% making some other product. Information was not given on proportion of total harvest dedicated to processing, nor percent of households that didn't do any. Determinants were access to training, and quantity of sweetpotato available. Alalade *et al.* (2019), also in the same LGAs in Kwara State, Nigeria, conducted a survey on value addition by 145 households, and its effect on producer income. They reported that farmers who engaged in value added activities made more than those that sold at farm gate, but that those with greater production also made more. They recommended formation of farmer groups to take advantage of training on production and value addition, market opportunities, etc.

An extensive literature review of Nigerian literature by Bergh *et al.* (2012) covers all aspects of statistics, production, marketing and value addition and presents somewhat contradictory and incomplete information. The paper draws a little more heavily on southern information than northern, focusing heavily on Kwara state. Attempts to include gender were made but are somewhat confusing with statements that "most farmers are male smallholders with limited education", alongside "women currently play a large role in production". They concluded that sweetpotato processing offers many opportunities. Dried chips production is widely practiced, but fried product production is viewed as very promising. Fried sweetpotato is cheaper than fried yam and fried potato.

Omoare *et al.* (2015) conducted a survey of 750 households in Ogun, Osun and Kwara States. Sixtythree percent of respondents were female. Almost all respondents consumed sweetpotato (46% cream fleshed, 32% white fleshed, 21% OFSP). Ninety-nine percent didn't know that OFSP was rich in provitamin A. Eighty eight percent of respondents consumed boiled, roasted and fried and sundried chips. Chips were eaten at least weekly by 45% of respondents, and flour (presumably amala) by 60%. Animal fodder was used daily by 62% of respondents. Households that were food secure were sweetpotato consumers [had chips on hand]. The authors recommended educational programs to encourage more consumption of OFSP.

A value chain assessment done in Nigeria for SASHA to identify areas of possible value chain investment (Onumah *et al.*, 2012) was introduced in the previous section. The authors interviewed many actors and put together a picture of current production, marketing and utilization. They also made recommendations for value chain investments or areas of focus. They recognized that most of the crop is currently sold for home consumption where it mostly boiled or fried. Also, they recognized a burgeoning street chunk fry business as well as the potential for higher end frozen French fries for the fast food sector. Further, they saw the chips/crisp market as a key area for more investment. They did not comment on quality requirements.

An unpublished study of 170 marketers and 200 producers in major sweetpotato-producing LGAs in Kano State (CDA, 2017) revealed the great importance of the crop to both marketers and producers, many of whom reported that sweetpotato marketing or production was their major source of income,



with production on-going throughout the year due to availability of irrigation. All 200 producers ranked sweetpotato as their first source of income and mean sweetpotato production area was just under two hectares.

During a rapid assessment conducted in Nigeria, Ghana and Burkina Faso, Peters (2013) recognized the current and increasing importance of sweetpotato as a commercial crop in these countries, and also estimated that a high proportion of sweetpotato was chunk fried in each country (Table 5). She had specific recommendations for commercially-oriented (participatory variety development with fryers) interventions and nutrition-oriented (higher dry matter, higher yielding OFSP) interventions and animal feeding (dual purpose types).

Table 5. Aspects of sweetpotato commercialization and use with implications for variety requirements in Nigeria, Ghana and Burkina Faso (from Peters, 2013 and 2015).

	# yrs. SP as cash crop	Ways SP are consumed	Market access	Variety requirements	Current varieties	Yield (metric tons/ha)
Nigeria	< 10	Fried (60%) Boiled (40%)	Four major cities plus the local markets	Long shelf life (2-3 weeks) due to long chain; Sweet taste	2 target national markets	I Avg: 6.8* II Avg: 3.7 III Avg: 3.6
Ghana	5-10	Fried (80%) Boiled (20%)	Spread out around the country	Medium shelf life (1-2 wks); Fry well; Bright color	Diverse varieties with no champion	North Avg: 7.2 South Avg: 14.1
Burkina Faso	15	Boiled (70%) Fried (30%)	A few particular provinces	High DMC Sweet taste	2 target national markets	Avg: 19.5

*These refer to the three classes of sweetpotato farmers: Type I. specializes in SP production as a cash crop, targets national markets with one or two specialized varieties. Type II. produces SP as one of the cash crops, various varieties targeted for local markets. Type III. produces SP as a consumption crop but still sells a big portion of it

5 CONCLUSION AND RECOMMENDATIONS

This review of the state of knowledge of fried sweetpotato, with an emphasis on chunk fried sweetpotato in West Africa provides a number of insights into the "state of the art" of sweetpotato fried products globally, including vacuum frying, and production of chips and French fries. We found very little literature specifically related to fry quality for chunk fries in West Africa, but information from the literature reviewed will help to guide our efforts to develop a clear product profile for sweetpotato chunk fries in West Africa, and may also help guide the development of West African product profiles for chips and French fries, as these markets are already in the process of developing. The review of literature and interviews with key informants emphasize the relevance of fried products in West Africa, where large portions of the crop end being processed into chunk fries by predominantly female processors for sale as street food. Further detailed survey work involving producers, processors and consumers will help to provide clarity on whether there are different sets of practices and preferences by gender, country, and regions within countries, and whether different attributes are required for good fried and boiled sweetpotato. Relating these findings to



physicochemical characterization of raw and fried sweetpotato, and to sensory characterization of fried sweetpotato will allow us to gain clear insights into consumer quality preferences for fried sweetpotato, and to apply these to improve targeting and efficiency of sweetpotato breeding efforts to develop nutritionally superior, consumer-preferred varieties.

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