Breeding and Prospects for Low Sweet Sweetpotato in West Africa

- A trained sensory panel was developed to assist with breeding for sweetpotato quality preferences of consumers in West Africa.
- Lexicons of terms to precisely describe boiled and fried sweetpotato sensory quality have been developed using trained sensory panel.
- Trained panel results showed that there is no direct relationship between sugar content and sweetness in boiled sweetpotato.
- Results showed that consumers liked the new high yielding varieties ranging from sweet to low sweet.
- Different clusters of consumer preference were detected and will help targeting of breeding efforts.

SASHA Sweetpotato Action for Security and Health in Africa

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Fig 1. Trained panelist evaluating fried sweetpotato using the lexicon of descriptive terms developed by the panel. (Credit E. Agyeman)

What was the problem?

Prior to the establishment of the SASHA breeding platform for West Africa in Ghana, experienced colleagues from the region told us that sweet taste, meaning a sugary taste, was a constraint to wider sweetpotato adoption in this region, where low sweet starchy staples such as cassava and yam predominate. So breeding for low sweet taste became a focus of our breeding effort, which did not exclusively emphasize orange-fleshed sweetpotato (OFSP) but included other flesh colors as well. We had low sugar germplasm from global and local sources (Ghanaian varieties were not very sweet), and we had laboratory equipment for the rapid determination of sugars in samples from our trials, which we assumed would help us efficiently select low sugar/low sweet genotypes. We knew, however, that sugars in sweetpotato can change during cooking as starch is converted to the sugar maltose, so we needed to update our methods to be able to rapidly determine sugars in cooked samples. Furthermore, breeding trials were underway using participatory approaches, and we were surprised when farmers and other consumers told us that they liked most of the varieties we offered them, including sweet ones. We realized we didn't have a clear enough understanding of the sweetpotato quality preferences of consumers in Ghana and West Africa where sweetpotato is primarily eaten boiled or fried, so needed more information to be able to guide our breeding effort. We also needed to know how we could most efficiently breed to meet consumer preferences through the use of laboratory techniques (such as measuring sugars) or other approaches.

What objectives did we set?

To help us in our effort to effectively breed to meet consumer preference in Ghana, we turned to the tools of food science. We recruited and trained a sensory panel of 10 to 12 individuals with the ability to precisely distinguish sensory characteristics (appearance, taste, texture, mouthfeel, and aroma). We then used this panel to develop vocabularies (lexicons) to describe sensory attributes of boiled and fried sweetpotato using a broad range of sweetpotato germplasm available to us. We included yam as a reference given its importance in Ghana, and similarity of use to sweetpotato in boiled or fried forms. Our lexicon for boiled sweetpotato currently has 30 terms while that for fried sweetpotato has 22 (Fig. 1). Multivariate statistical approaches allow us to picture the "sensorial space" for boiled or fried sweetpotato, and to map sweetpotato varieties onto that space (Fig. 2). We can now take existing and new varieties from the breeding program and present them to groups of consumers to tell us whether they like them or not (Fig. 3). We thus gain insights into the characteristics of the varieties that consumers like, which may vary depending on socioeconomic or other characteristics, and we can gain insights on how to efficiently breed for the combination of sensory characteristics desired by consumers in a good variety.

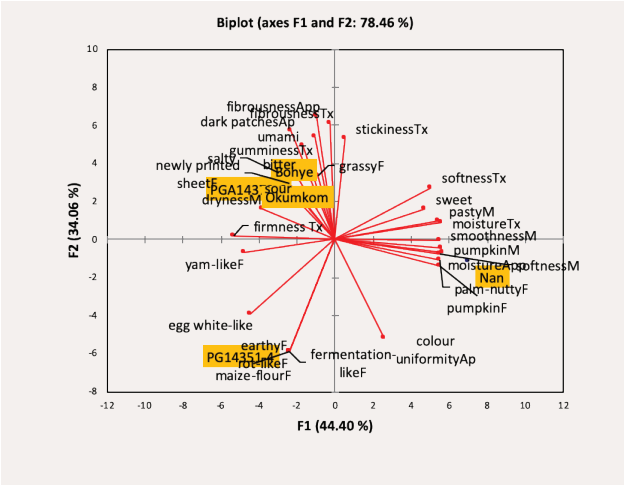

Fig 2. Multivariate presentation of sensory traits (red lines) in the lexicon for boiled sweetpotato developed by a trained sensory panel, with 5 varieties (yellow) positioned in the sensorial space.

With our trained panel and consumer surveys, we can get a clearer understanding of how important sweetness is to consumers in Ghana and elsewhere in West Africa. And we can also examine the relationship between sweetness as measured by the trained panel, and sugars measured in the laboratory to know if the laboratory techniques we have been using to select for sweetness are appropriate. For categorizing sugars in the lab, we used the approach of Kayes et al. (2005) based on sucrose equivalent (SE) on a dry weight basis (dwb). Non-sweet is less than 12% SE; low sweet 13 to 20% SE; moderately sweet 21 to 28% SE; high sweet 29 to 37% SE; and very high greater than 38% SE.

Where did we work?

Our sensory tools were an add-on to the on-going collaborative breeding effort in Ghana, conducted with partners from the CSIR-Crops Research Institute and CSIR-Savanna Agricultural Research Institutes under SASHA since 2010. The accelerated breeding pipeine delivers varieities to the advanced and on-farm trial stages, where inputs by producers, processors, and consumers help to guide decisions about release. Genotypes that are superior to the current leading varieties or which have potential in a new niche, such as purple flesh color, are put forward for release and dissemination. The testing network in Ghana covers major production zones In the northern and the southern agroecologies. Efforts of the program have also focused on developing delivery systems (commercial seed systems) and demand, mainly for orange-fleshed sweetpotato in order to help combat vitamin A deficiency with this biofortified crop. The consumer sensory evaluations reported here were conducted in urban centers where we presented a set of 5 varieties with varying flesh color and sweetness (the varieties presented in Fig. 3 and 6) to over 700 consumers in boiled or fried form and asked them for their preferences.

What did we achieve during SASHA Phase 2?

The first thing we found out with our trained sensory panel was that there is little relationship between the perception of "sweetness" and the actual sugar content of the genotypes evaluated, meaning that analyzing all of our boiled root samples for sugars was not really helping us to identify genotypes that were more or less sugary (Fig. 4). This does not mean that sugars have no importance to sweetpotato sensory qualities, since we know that certain types of sugars contribute to browning during frying of sweetpotato, and aromatic compounds produced from sugars during cooking contribute strongly to aroma and perhaps taste. We also observed (data not shown here) that, following cooking, there was a significant reduction in starch content, with a much smaller increase in maltose (the sugar resulting from enzymatic breakdown of starch) during cooking.

The next findings came from consumer sensory evaluations of boiled and fried sweetpotato in urban centers including Accra and smaller towns in regions where sweetpotato is important (Fig. 3 and 6). For boiled

Fig 3. Consumers at Kaneshie market, Accra, evaluating sweetpotato fries. (Credit E. Kuuna Dery)

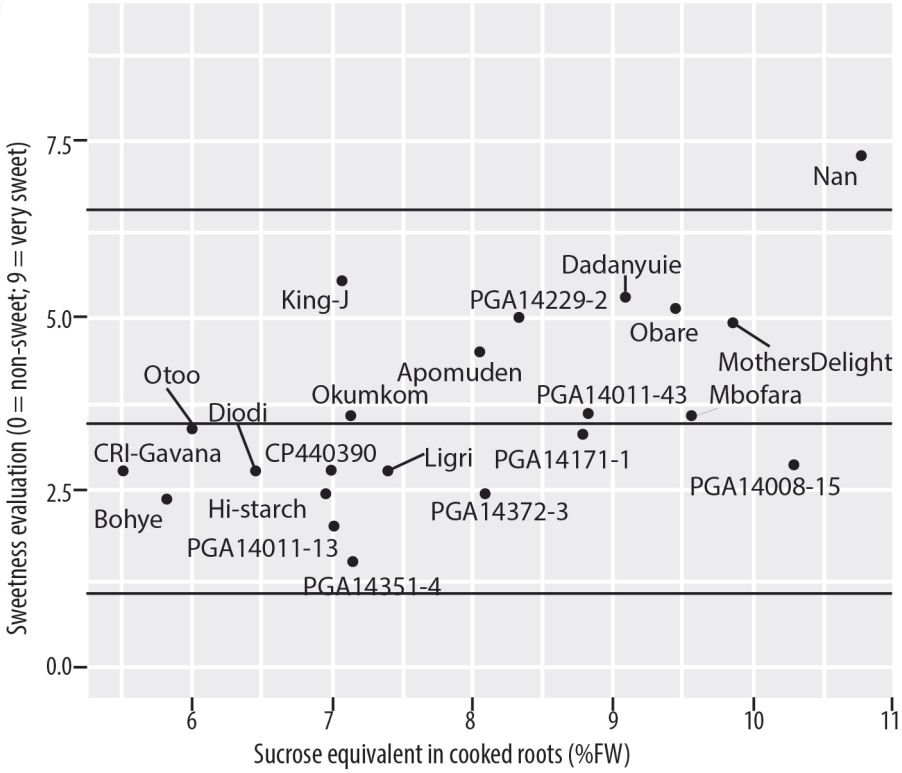

Fig 4. Sugar content (expressed as sucrose equivalent since different sugars have different levels of sweetness) and sweetness evaluations by a trained panel showing a weak relationship between sweetness and sugar content in boiled sweetpotato. Horizontal lines represent sweetness categories with low sweet between the middle and lower lines, and moderately sweet between the middle and upper lines.

sweetpotato, consumers overall preferred the moderately sweet Okumkom, followed by the sweeter Nan, and the low sweet PGA14372-3, with the least sweet genotypes, Bohye and PGA14351-4, least preferred (Fig. 5). However, clusters of preference could be distinguished, with some consumers preferring the the least sweet types. Mapping the clusters to the sensorial space generated by the trained panel provided information on the sensory attributes (from the lexicon) that helped to distinguish the preference clusters. A cluster was associated with Nan (the OFSP), and 13 traits from the lexicon, including appearance (1), aroma (4), mouthfeel (4), texture (3) and the basic taste, sweetness (1), contributed more stongly than others to differentiate this cluster. Another preference cluster, was associated with the low sweet PGA14351-4, and 7 different traits, including appearance (3), texture (3) and umami or savory taste[1] contributed strongly to defining this cluster. For fried sweetpotato, Nan was preferred over other genotypes, with appearance contributing heavily to this positive evaluation. Preference clusters were associated with the contrasting genotypes Nan and Bohye, with 10 traits contributing strongly to the first cluster and 8 different traits to the second.

Encouraging results from the SASHA breeding effort in Ghana include the selection and release of superior varieties, including Nan, a higher dry matter OFSP, which is being rapidly adopted. More superior genotypes bred in Ghana are reaching the advanced stages of selection. For example, PGA14372-3, one of the genotypes included in our consumer sensory survey, was the top-ranked genotype both agronomically and with respect to boiled eating quality in second year farmer-participatory on-farm trials in northern Ghana in 2018. It, along with at least one other highly ranked candidate, will be put forward for variety release in 2019.

Key challenges and lessons learned

During the course of SASHA, we have learned how to breed sweetpotato in the challenging environments of West Africa, including mastering crossing, and identification of testing locations, with advances made more rapidly in the north than the south. Our breeding efforts are generating varieties that are highly acceptable to consumers in both boiled and fried forms, with a range of quality traits, including low and high sweetness, and a range of flesh colors. We have also made strides to improve our ability to target consumer preferences and breed for quality traits. However, more work is required to target consumer preferences and breed for quality traits. Progress will come in the context of demand-led breeding. Awareness of and interest in sweetpotato, particularly OFSP, is accelerating in Ghana, and is helping to create year-round markets (an increasingly important driver of adoption) for sweetpotato roots and processed products made from the crop. A comprehensive approach to sweetpotato demand development is required, particularly in the northern regions of Ghana and neighboring countries in West Africa, paying particular attention to women who play a key role in household food preparation, but may not be allowed to own land, limiting their role in driving sweetpotato adoption. Women in northern Ghana placed emphasis on selection of varieties for leafy green production as well as root yield.

[1] The taste receptors for umami are those that typically respond to glutamates, which are widely present in meat broths and fermented products and commonly added to some foods in the form of monosodium glutamate (MSG). Human breast milk, broths, gravies, soups, soy sauce, shellfish, fish and fish sauces, tomatoes, mushrooms, and cheeses have strong umami flavor.

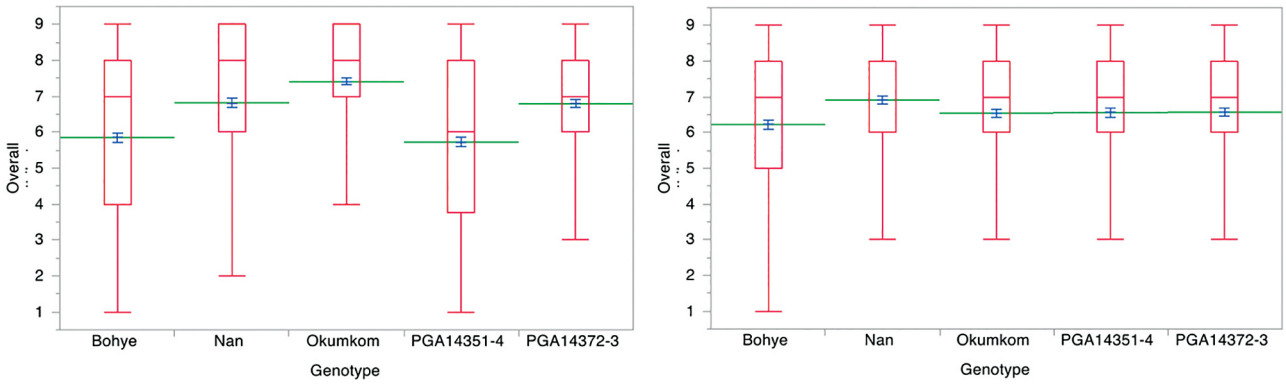

Fig 5. Sensory assessments (overall liking) of boiled (left, 378 evaluators) and French fried sweetpotato (right, 337 evaluators) genotypes in Ghana. Evaluations were done in Accra, Cape Coast, Akatsi and Baku. Box plots (in red) represent the data spread, while green lines represent mean values and standard errors are presented in blue.

What's next?

Next steps must include a greater regional focus to the breeding work of the Sweetpotato Support Platform for West Africa from its base in Ghana. Development of regional testing approaches guided by product profiles for targeting variety development/replacement in countries including Nigeria, Burkina Faso, Cote d'Ivoire, Sierra Leone and others, will be important. Continued application of the tools of sensory analysis will guide the targeting of quality objectives and the development of lower cost high and medium throughput laboratory techniques. The products of starch breakdown during cooking and their contribution to product quality certainly merit further investigation. Fried products are important in West Africa, and we and partners will place more emphasis on breeding for the quality attributes required by this market segment. Perishability of sweetpotato, including losses during storage and in market channels, is an additional major challenge that has been neglected by breeding in the past and which must now receive more attention.

Fig 6. Consumer sensory testing of boiled sweetpotato in the busy Akatsie market in the Volta Region. (Credit E. Kuuna Dery)

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Related publications:

Carey, E. et al., 2019. Developing and deploying non- and low-sweet sweetpotato varieties for expanding markets. Acta Horticulturae (in press).

Baafi, E., Carey, et al, 2016. Genetic incompatibilities in sweetpotato and implications for breeding end-user preferred traits. Australian Journal of Crop Science, 10(6), 887-894.

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